# INTRODUCTION

# CHAPTER 1

## INTRODUCTION

**EFFORTS TO SHORTEN ACQUISITION PROCESS FAILED**

An often discussed aspect of the acquisition process in the Department of Defense is the length of time it takes to develop and deploy weapon systems. Although there have been numerous" attempts to shorten this cycle, relatively little has been accomplished. The cycle has grown longer and the criticism stronger.

The reasons for shortening the cycle are directed mainly toward cost, and to some extent-though not enough-toward readiness. However, in the past few years, the issue of readiness has rightfully gained visibility and importance. Although the long acquisition cycle certainly is not a desirable situation, it might be tolerable if the process yielded satisfactory results. But most new weapon systems are less than satisfactory and require burdensome maintenance and logistics efforts. Even with the best of efforts, resultant low readiness often requires additional equipment in order to meet the needs of the Military Services. This is due primarily to a lack of "discipline in addressing logistics requirements during design and development.

**TRANSITION FROM DEVELOPMENT TO PRODUCTION IS THE PROBLEM**

In the acquisition process, first evidence of weapon system problems sometimes does not become apparent until a program transitions from full-scale development (FSD) into production. This transition erroneously is thought to be a discrete event in time. Most acquisition managers seem to recognize that there is a risk associated with the transition, but perhaps do not know the magnitude nor the origin, because the transition is not a discrete event but a process composed of three elements: design, test, and production. Many programs simply cannot succeed in production, despite the fact that they've passed the required milestone reviews. These programs can't succeed for technical reasons, notwithstanding what is perceived as prior management success related to DoD acquisition policy. A poorly designed product cannot be tested efficiently, produced, or deployed. In the test program there will be far more failures than should be expected. Manufacturing problems will overwhelm production schedules and costs. The best evidence of this is the "hidden factory syndrome" with its needlessly high redesign and rework costs. In addition, field failures will destroy operational and training schedules and increase costs.

The transition process is very broad and it is impacted by activities that are, or more accurately, are not done in the early design and test activities. For contractors who have been successful in designing and producing acceptable products, it generally is recognized that the control techniques needed to successfully complete the design, test, and production elements dictate the management system needed to direct the overall effort. In fact, the current management systems in today's industrial processes had their origins in these design, test, and production requirements.

### DoD CORRECTIVE MEASURES HAVE FOCUSED ON MANAGEMENT FIRST

Corrective measures by the Department of Defense have focused on establishing a series of management checkpoints and review activities. This becomes apparent when the acquisition process is reviewed, beginning with the management perspective in DoD Directive 5000.1 (reference (a)) and DoD Instruction 5000.2 (reference (b)); descriptions of the Defense Systems Acquisition Review Council (DSARC) and related procedures; and the wealth of material that is available on the planning, programing, and budgeting system (PPBS) and other elements of defense planning, budgeting, and funding processes. This approach has been responsible for adding numerous layers of management, and has tended to compartmentalize, matrixize, and polarize the major areas of the acquisition process: design, test, and production.

These documents and the requirements that they spell out are important in that they establish a management grid that the various participants in the acquisition process must follow. However, they do not describe the industrial process, nor do they provide intelligence on the management and control of those technical activities and their related details that can either make or break a program. What has evolved as today's management system for material acquisition hardly recognizes the importance of development and production, much less does it utilize the vast resources of development and production data in any decision process. "Manage the fundamentals of design, test, and production and the management system will describe itself." However, and this is a particularly important point, the converse can never be true! It is impossible to describe the management system first that will take care of the fundamentals of the industrial process-engineering and manufacturing.

This patently is obvious when the management system used by the Department of Defense and its Military Services is reviewed. Yet, it seems to be the subject of continued and ongoing interest at ail levels of both the Department of Defense and the Military Services. The central cry heard in the halls of the Pentagon when things go wrong is "reorganize, restructure the management system." Some think that if enough organizational boxes or enough people are moved, the problem will go away. Of course, it doesn't, yet those responsible for creating the organizational mess think so. Consequently, we are left with a legacy that only grows worse with time. Why is this the case? Most probably because it is the path of least resistance.

The current review process, culminating in a DSARC decision for major programs, has no structural mechanism that can articulate with any degree of certainty the risk associated with the engineering and manufacturing elements of the weapon system acquisition process.

**CAUSES OF ACQUISITION RISK ARE TECHNICAL, NOT MANAGERIAL**

Some communities have suggested that the problem is mainly one of delivering weapon systems that are too complex, and that reducing complexity would increase readiness. However, a recent Defense Science Board (DSB) summer study deliberated the issue of complexity versus readiness and concluded that although there is a relationship, it is relatively small and threat-driven. It was suggested that the probable cause is inadequate engineering and manufacturing disciplines combined with improperly" defined and implemented logistics programs. This industrial process of weapon system acquisition demands a better understanding and implementation of basic engineering and manufacturing disciplines. Once rigorous, disciplined engineering practices are employed and institutionalized, both the risk of deploying unsuitable weapon systems and the time in the acquisition cycle associated with design, test, and production will be reduced.

Current DoD systems acquisition policies do not account for the fact that systems acquisition is concerned basically and primarily with an industrial process. Its structure, organization, and operation bear no similarity whatsoever to the systems acquisition process as it is described conventionally. It is a technical process focused on the design, test, and production of a product. It will either fail or falter if these processes are not performed in a disciplined manner, because the design, test, and production processes are a continuum of interrelated and interdependent disciplines. A failure to perform well in one area will result in 'failure to do well in all areas. When this happens-as it does ail too often-a high risk program results whose equipment is deployed later and at far greater cost than planned.

The answers to these problems won't be found in another revision of DoD Directive 5000.1 (reference (a)) or DoD Instruction 5000.2 (reference (b)). Nor will they be found in adjustments to the DSARC or other administrative procedures. They won't be found in these areas, because the problems are technical, not managerial.

**DSB TASK FORCE CORRECTIVE MEASURES FOCUS ON TECHNICAL SOLUTION**

The Under Secretary of Defense for Research and Engineering (USDR&E) recently has expressed more and more concern regarding this transition phase. Consequently, a task force was formed under the auspices of the DSB to review the various subsets of the transition from development to production. The formal terms of reference are summarized as follows:

- Examine ways and methods that will define more clearly and accelerate the transition from development into production.
- Direct the inquiry toward both the producing industry and the administering Government agency.
- Recommend those disciplines and controls for application in those activities comprising design, test, and production that result in the timely delivery of a quality product to the operating forces.

**TEMPLATES MINIMIZE HIGH TRANSITION PHASE PRODUCT RISK**

The major thrust of the DSB report is directed toward the identification and establishment of critical engineering processes and their control methods. This will lead to a more organized accomplishment of these activities and will place more significance and accountability on them. In order to do this, the task force generated a matrix of the most critical events in the design, test, and production elements of the industrial process. These events were then transformed into what are referred to as "templates," a term that defines their nature and intended use.

The undertying principle of this approach is the recognition that everyone in the Department of Defense and ail of its contractors sincerely want to do a good job. If the proper environment exists and the necessary tools to accomplish the work are developed, satisfactory products will be forthcoming. Having first established these fundamentals as a reference point, it is now necessary to ensure the right environment, which in this case, is a matter of obtaining adequate visibility, and establishing the tools, which by their use form a frame of reference to evaluate their proper application. In this case, the tools are the templates.

Figure 1-1. represents the DSB task force perspective of the transition problem and the action level that must be reached in order to define understandable and achievable engineering solutions to repetitive transition risks. The key here is to recognize that risk is eliminated only when the industrial process is changed, and that change is effected at a level of detail normally not visible to the technical decision maker. Understanding for this crucial point is paramount to electing the low risk course of action.

The templates describe techniques for improving the "acquisition process" by recognizing it for what it is-an industrial process concerned with the design, test, and production of low risk products.

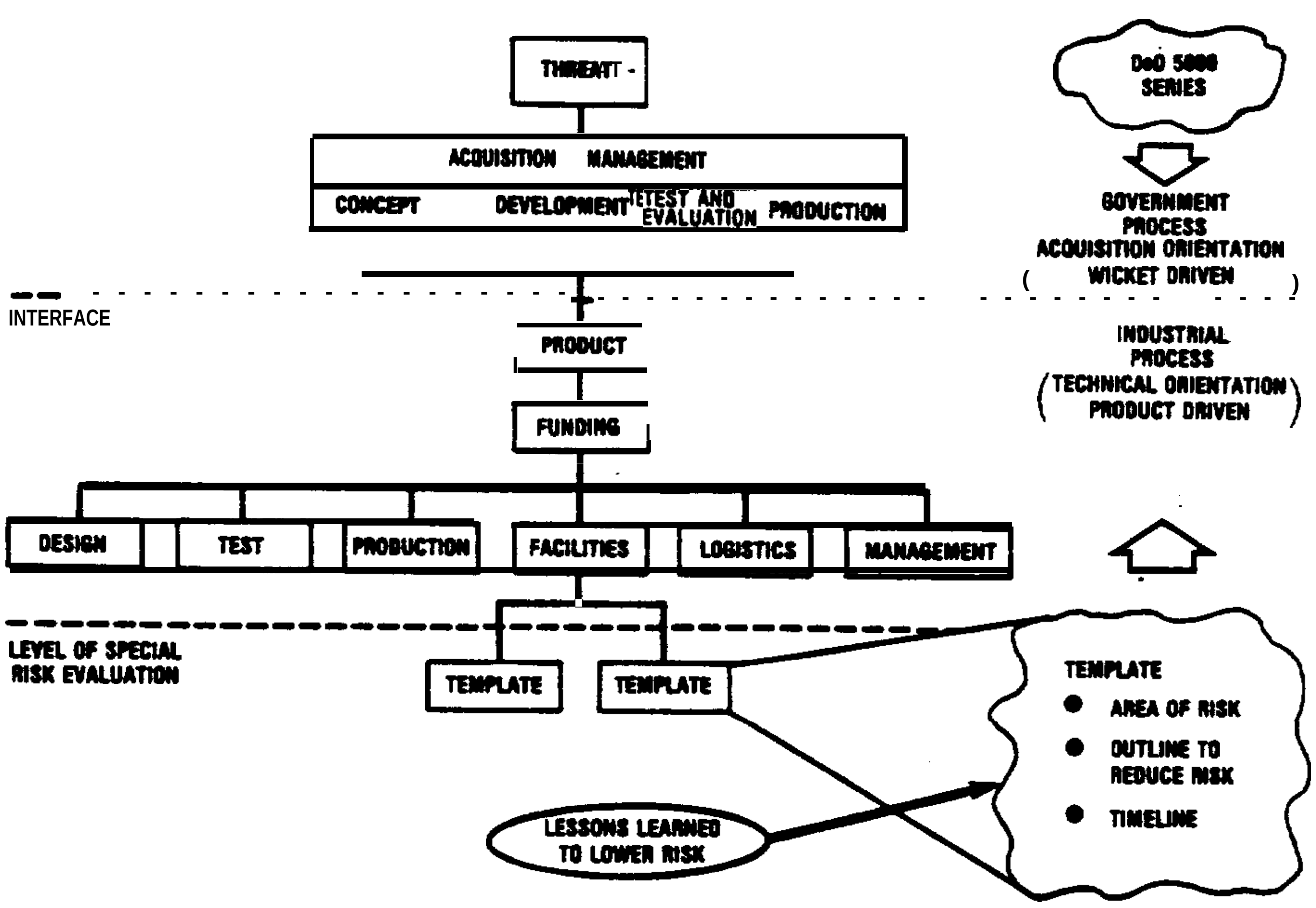



Figure 1-1. Transition Problem Perspective and Action to Lower Product Transition Risk

Selected areas of this document stress the electrical and electronic disciplines because of the significant role that the electronics field is playing in improving system effectiveness and productivity. Recent surveys have shown that the majority of the key technologies affecting future weapon system capability and DoD budgets are in the electronic fields. These technologies include such disciplines as very high-speed integrated circuits, advanced software and algorithms, machine intelligence, and space-based and short wave-length radars. However, emphasis shall be placed on maintaining program technical balance within all disciplines.

Specific attributes override all detail requirements. These are (1) assurance of design maturity, (2) measurement of test stability, and (3) certification of manufacturing processes. Design maturity is a qualitative assessment . of the implementation of contractor design policy: Test stability is the absence or near absence of failures in development testing of a stable design. Certification of the manufacturing processes implies both design for production and proof of process that occur during pilot production (concurrency). Each of the above attributes is a function of the proper application of all of the . templates identified in the design, test, and production sections of this document.

**TEMPLATES ARE BASED ON TASK FORCE EXPERIENCE**

The templates were initiated using the reports of the five panels that made up the DSB task force. The total set of recommended initiatives and principles were tested against their relationship to "technical risk," using the background and knowledge of the members of the task force as the basis for defining these technical risks and for setting out methods for minimizing them during the transition from development to production. From the results, a set of templates was developed for use in describing low risk programs. A low risk program is a program that is not likely to give trouble during the transition out of development.

Each template describes an area of risk and then specifies technical methods for reducing that risk. The templates themselves are nominally two- or three-page documents that usually describe a technical problem that in turn creates a high risk program. The templates then describe a readily available technical solution to the problem based on the lessons learned from analysis of a substantial number of programs.

Justification for the use is. then provided along with supporting --- data.

Throughout this document there are timelines for many template activities that begin and/or end between two major milestones. In such cases, the timeline is depicted for simplicity purposes as beginning and/or ending in the middle of the program phase. It is left to the users of this document to determine how early or how late in the phase the tempiate activity begins or ends; and such a determination will be influenced by the type of program, the acquisition plan, and the best" judgment of experienced Government and industry personnel.

The subsequent pages of this document contain all the templates generated by the DSB task force to reduce risk inherent in the design, test, and production processes. Additional templates have been generated as a result of a DoD and industrywide review. Since some risk is associated with funding, facilities, management issues, and the transition plan for design, test, and production, the entire network of templates is arranged in a sequence considered logical from a typical program manager's viewpoint. Funding is presented first because it influences every other template in the transition document. The total network of critical path templates is shown in figure 1-2.

**TEMPLATE APPLICABILITY IS CORRELATED WITH ACQUISITION PHASES AND MILESTONES**

In figure 1-3, the time phasing associated with development of each of the templates is identified as the program progresses through the material acquisition cycle. Program risk is introduced when a particular template activity is started after or continued beyond the timeline. For those less familiar with the DSARC process and its typical relationship with program phasing, the conceptual phase begins after the justification for major system new start (JMSNS) is approved. Between Milestones I and II, the demonstration/validation phase occurs and Milestone II is the beginning of FSD. The production phase begins at Milestone IIIA (tooling, long lead time, and pilot production) notwithstanding the production preparations that must begin early in the FSD phase, and Milestone IIIB generally signifies the beginning of rate production.

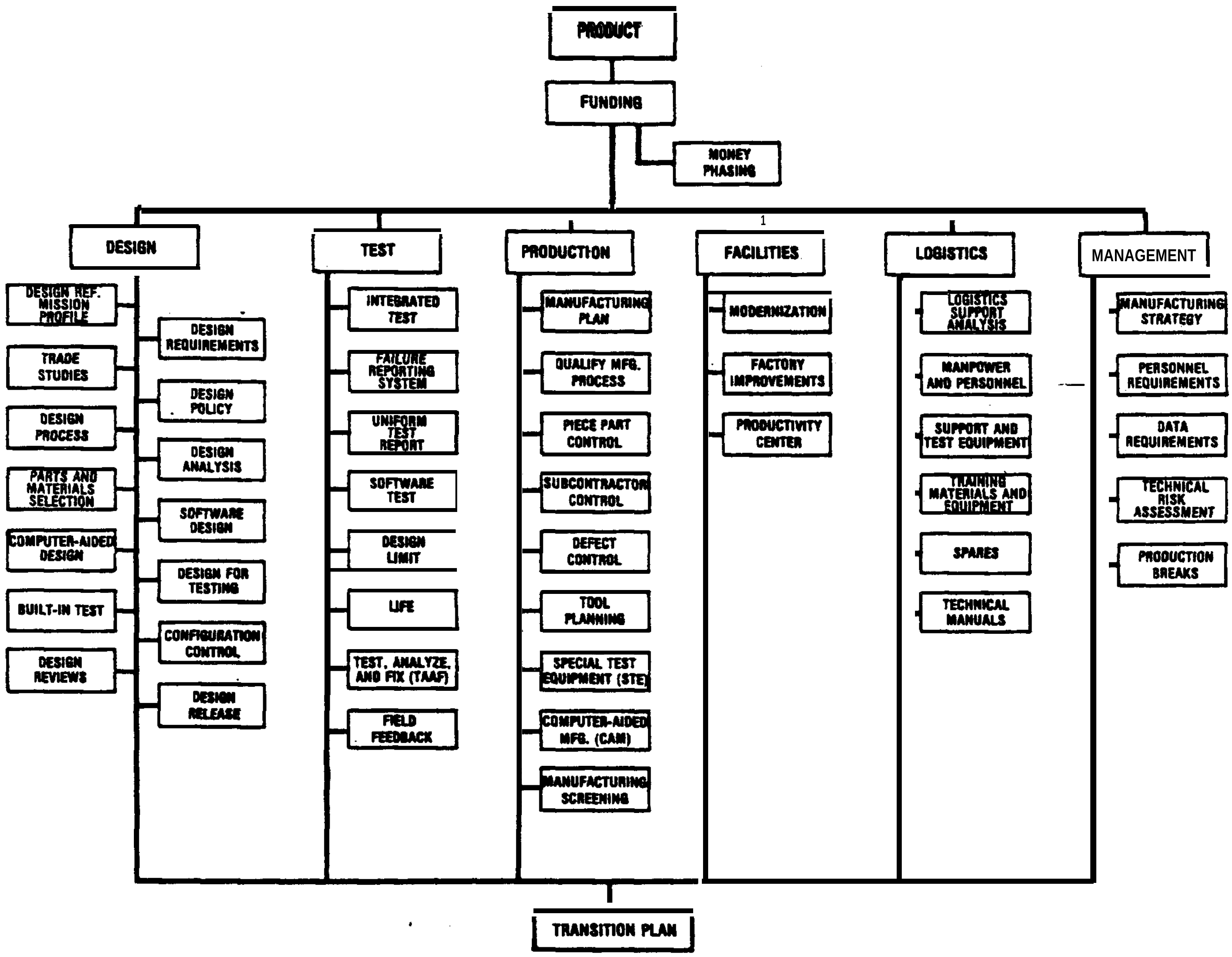
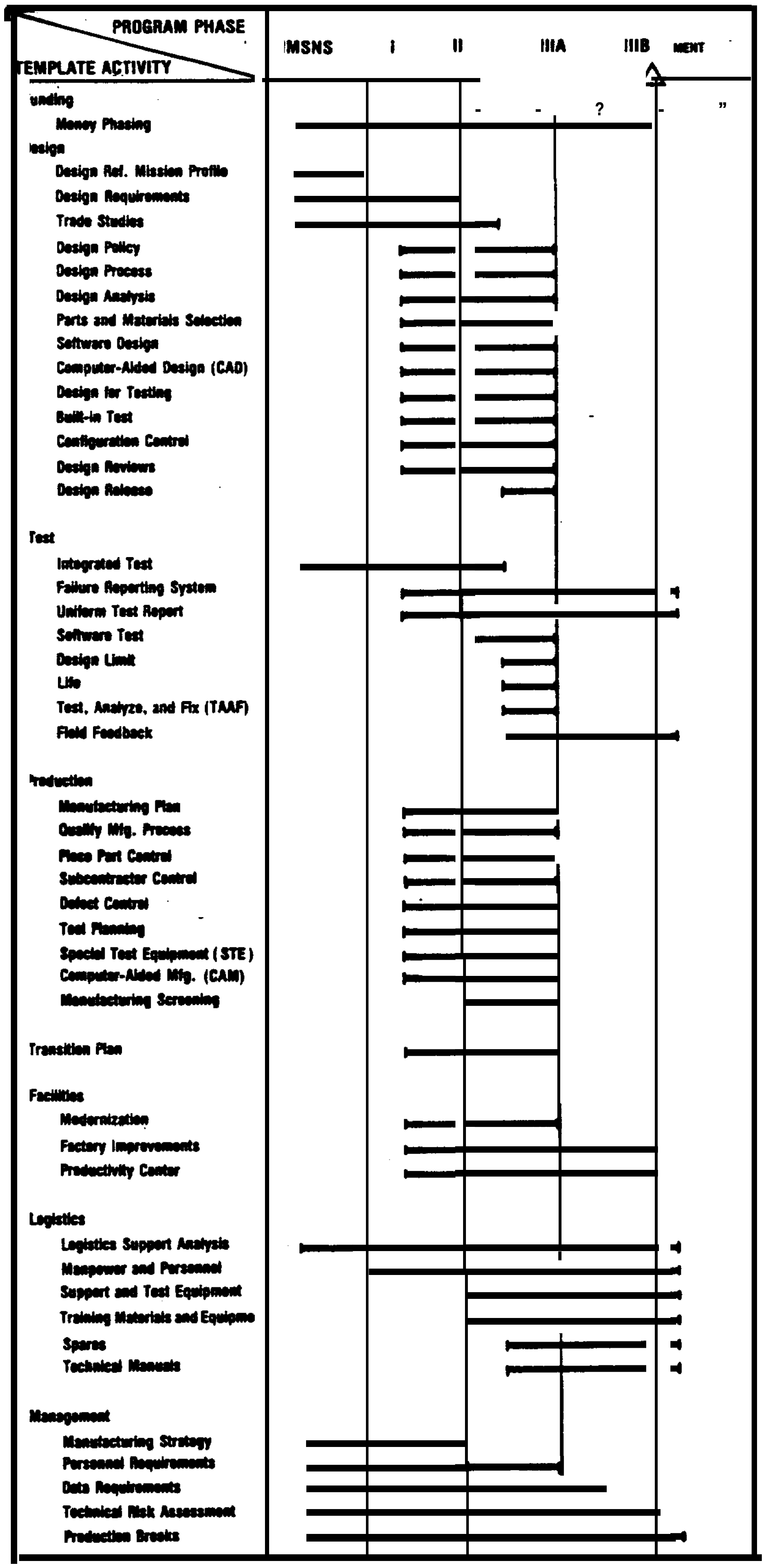



Figure 1-2. Critical Path Templates




PROGRAM RISK IS INTRODUCED WHEN A PARTICULAR TEMPLATE ACTIVITY IS STARTED LATE OR CONTINUES BEYOND THE TIMELINE

Figure 1-3. Template Timelines

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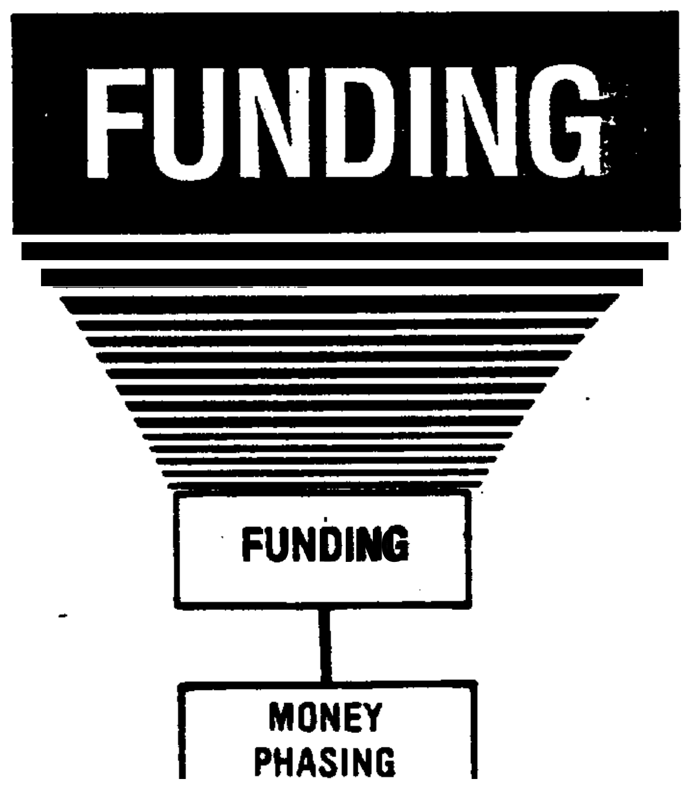
CHAPTER 2



# CHAPTER 2

## INTRODUCTION FOR FUNDING CRITICAL PATH TEMPLATE

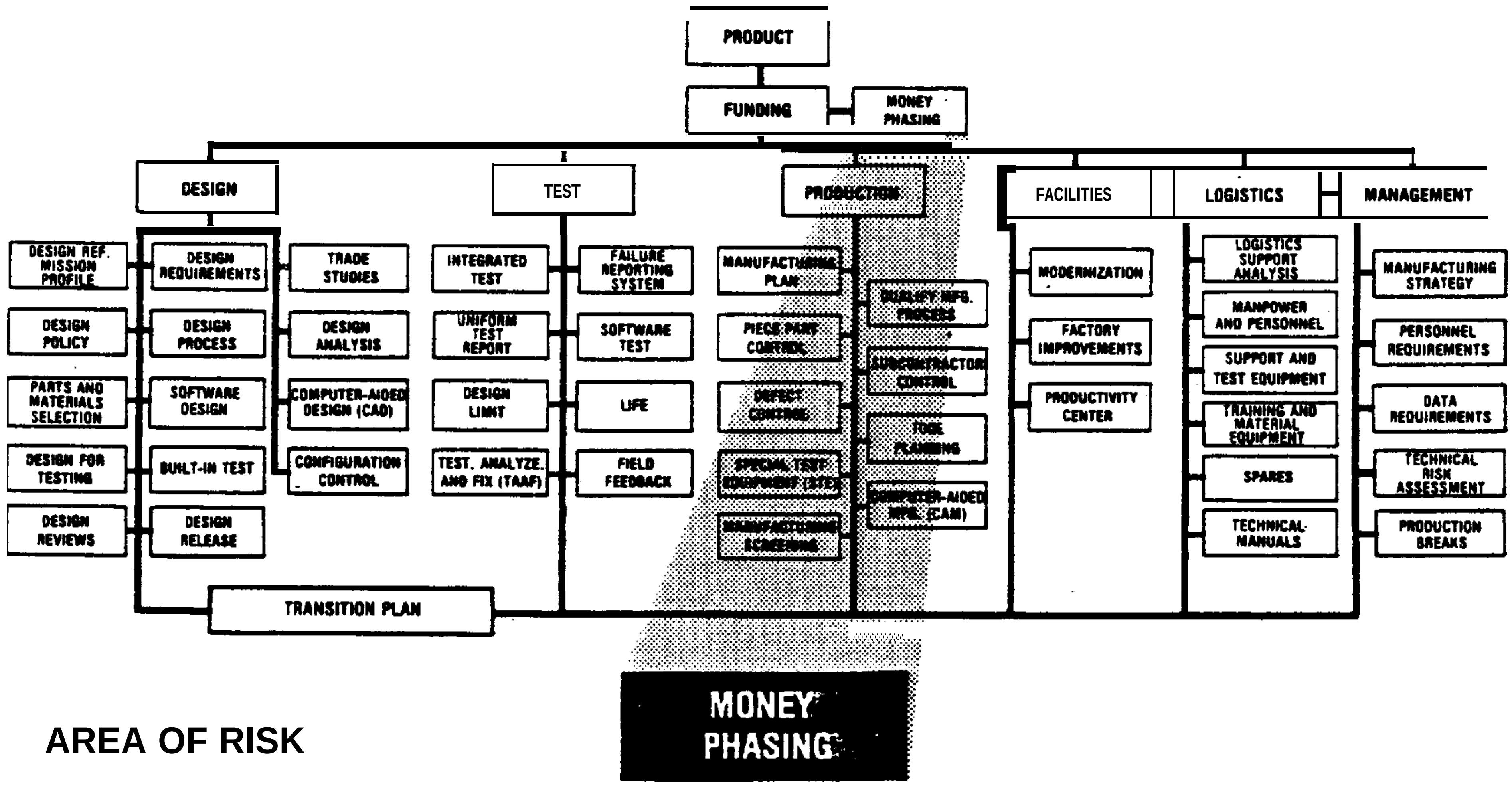
Over the years, the Department of Defense and the Military Services have been struggling to improve the acquisition process. There has been a seemingly endless proliferation of "blue ribbon" panels, ad hoc reviews, summer studies, task forces, and audits, whose memberships consisted of the most respected representatives of Government and industry. Many of these efforts were mandated congressionally, but the increasing congressional focus (General Accounting Office (GAO) reports and staff member inquiries) on DoD acquisition programs indicates that Congress is not convinced that the overall objective, namely, "more bang for the buck," is being accomplished.

There is no doubt that past studies and reviews have provided many practical recommendations and those that were acted upon helped formulate current procedures for the DSARC process and the PPBS. Yet, there is still concern whether the taxpayer's money is being well spent and whether our Armed Forces are being provided equipment that works when needed. Why do we have so many cost overruns and why does our operating equipment fail so frequently?

The answers are not simple. Some of the more lofty answers pertain to the increasing complexity of our hardware, greater administrative reporting burdens, changes in administration policy from one election to the next, and variations in the level of our international military commitment as it influences and is influenced by the existing attitude of the American public.

However, there are at least three answers that are not so lofty and over which we can exert significant control. One relates to the need for more discipline in the technical side of the acquisition process, that is, more attention to the engineering fundamentals of design, test, production, and supportability; this answer is the basic purpose of this Manual and is well described in the Preface and Introduction. A second answer involves the critical resource of personnel" and is discussed in a separate template in the Management section. The third answer is sound funding policy. In order to avoid "biting off more than we can chew," and because there are many facets to funding policy concerns, the following template on money phasing is confined to research, development, test, and evaluation (RDT&E), and initial production funding.

# TEMPLATE




## AREA OF RISK

Inadequate **RDT&E funding is, of course, an obvious major risk area. Aside from this "quantity" issue, however, there are the other funding risk areas that deal with the** *phasing* **of money: (1) inadequate** ***early*** **RDT&E funds, and (2) inadequate** ***early*** **production funds during the latter phases of development (initial production funds (IPF) and long lead). Risk is aggravated by authorizing development without production in mind.** *The development decision is a commitment to production* **that must be supported by properly phased funding.**

## OUTLINE FOR REDUCING RISK

- **If the all-important design and engineering effort is to be funded adequately, provide a reasonable proportion of total RDT&E funds in the eady years. Figure 2-1. is a representation of an idealized RDT&E funding profile.**

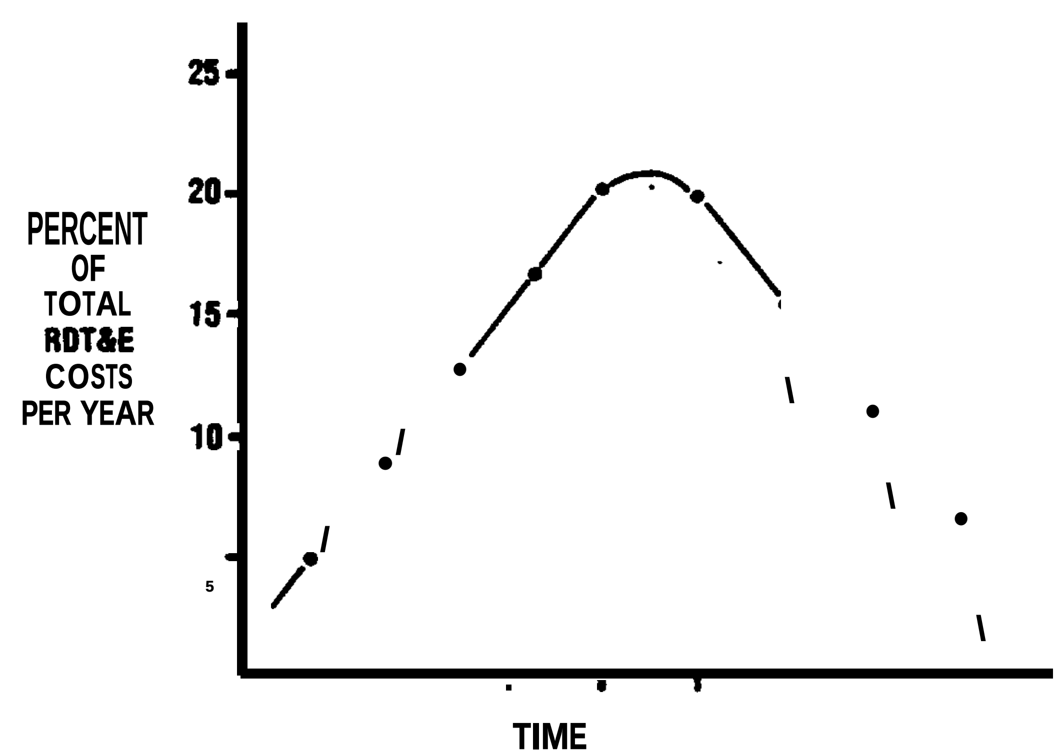



**Figure 2-1. What We Should Do (RDT&E Funding Profile)**

Rarely, however, are funds provided on this type of schedule. Early dollars are hard to find and the profile shown in figure 2-2. is a much more typical situation. This condition is aggravated when programs are started on short notice.

A significant initial subset of this profile is the RDT&E funding spent on production preparations. If this funding profile is changed, the impact on transition must be assessed.

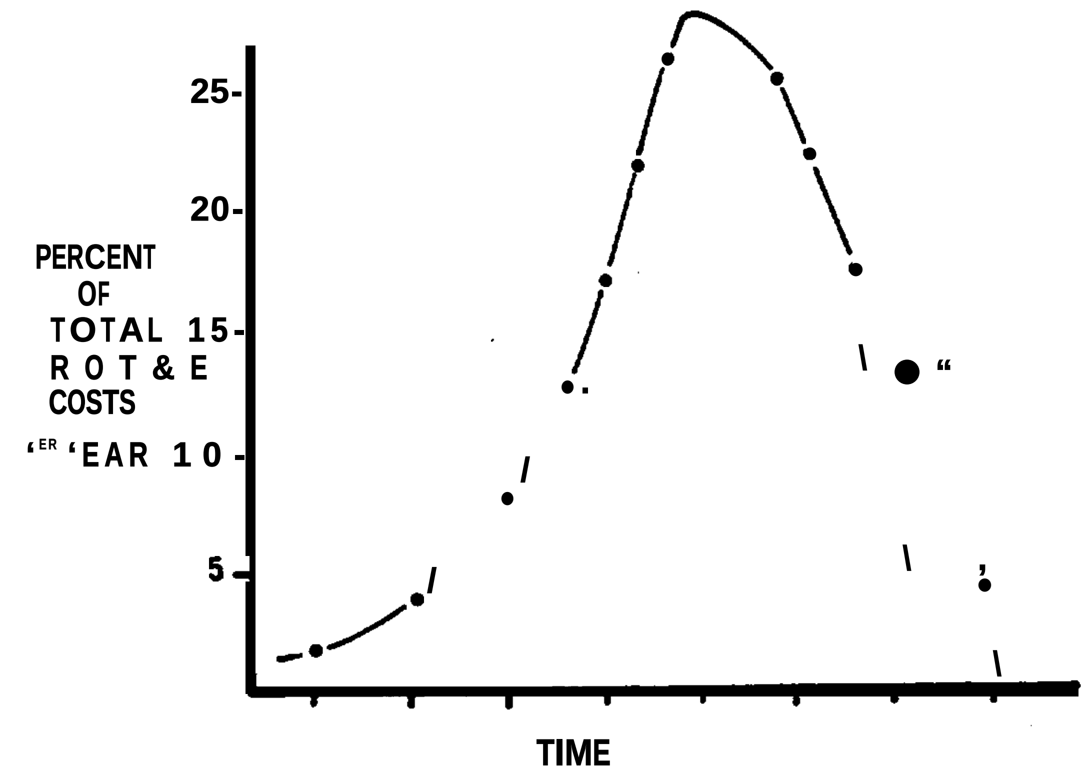



Figure 2-2. What We Do (RDT&E Funding Profile)

Figure 2-3. combines these *idealized* and *actual* funding profiles, and the shaded area represents a "design and engineering gap" from which the program cannot recover by application of later funds.

The first type of funding risk, therefore, can be ascertained by comparison of a program's funding profile with those of figures 2-1. and 2-2.

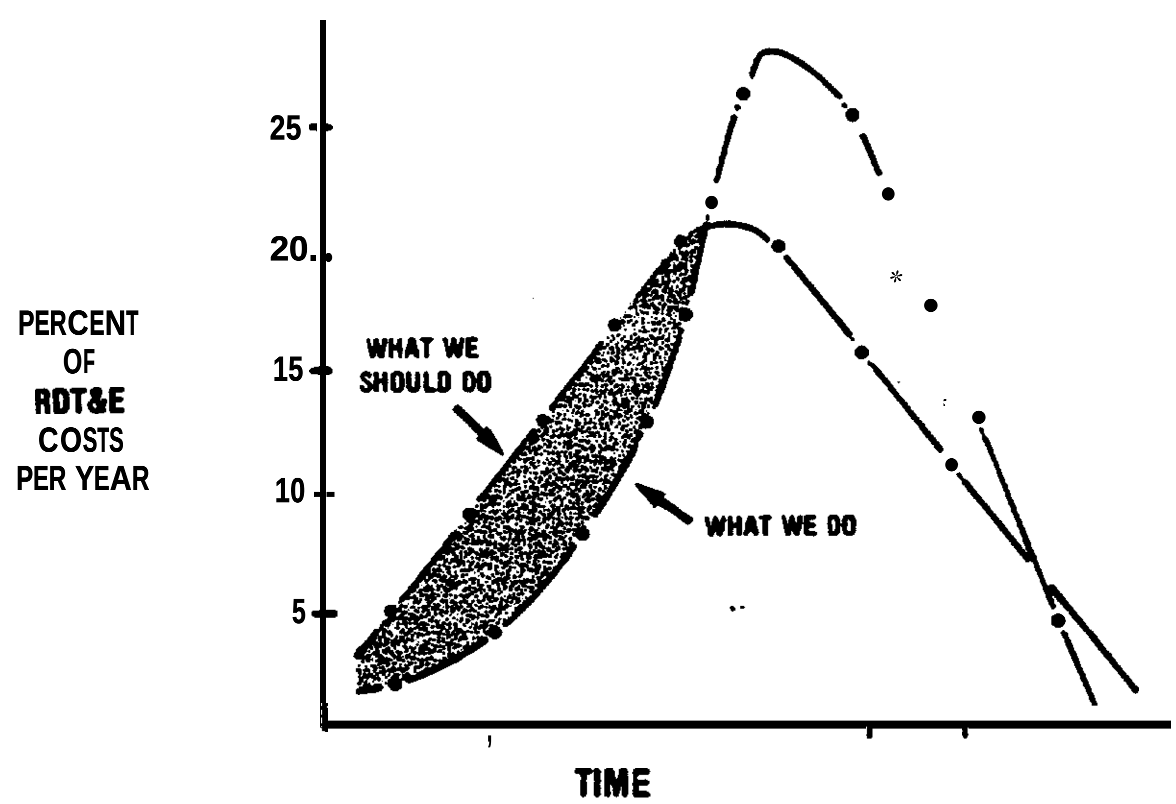



Figure 2-3. The "Design and Engineering" Gap

- The second type of risk reduction involves the early commitment of production funds-while development is still ongoing-for tooling, long lead materials, and production line startup. Figure 2-4. shows a graphic representation of the needed buildup of production funds during RDT&E phase down. The "fly before buy" school of acquisition policy tends to drive to the "too late" line. Excessive concurrency can result in unwise commitments indicated by the "too early" line. For all programs there will be an optimum middle ground that results in. low RDT&E risk and a controlled "transition to production" (shaded area).

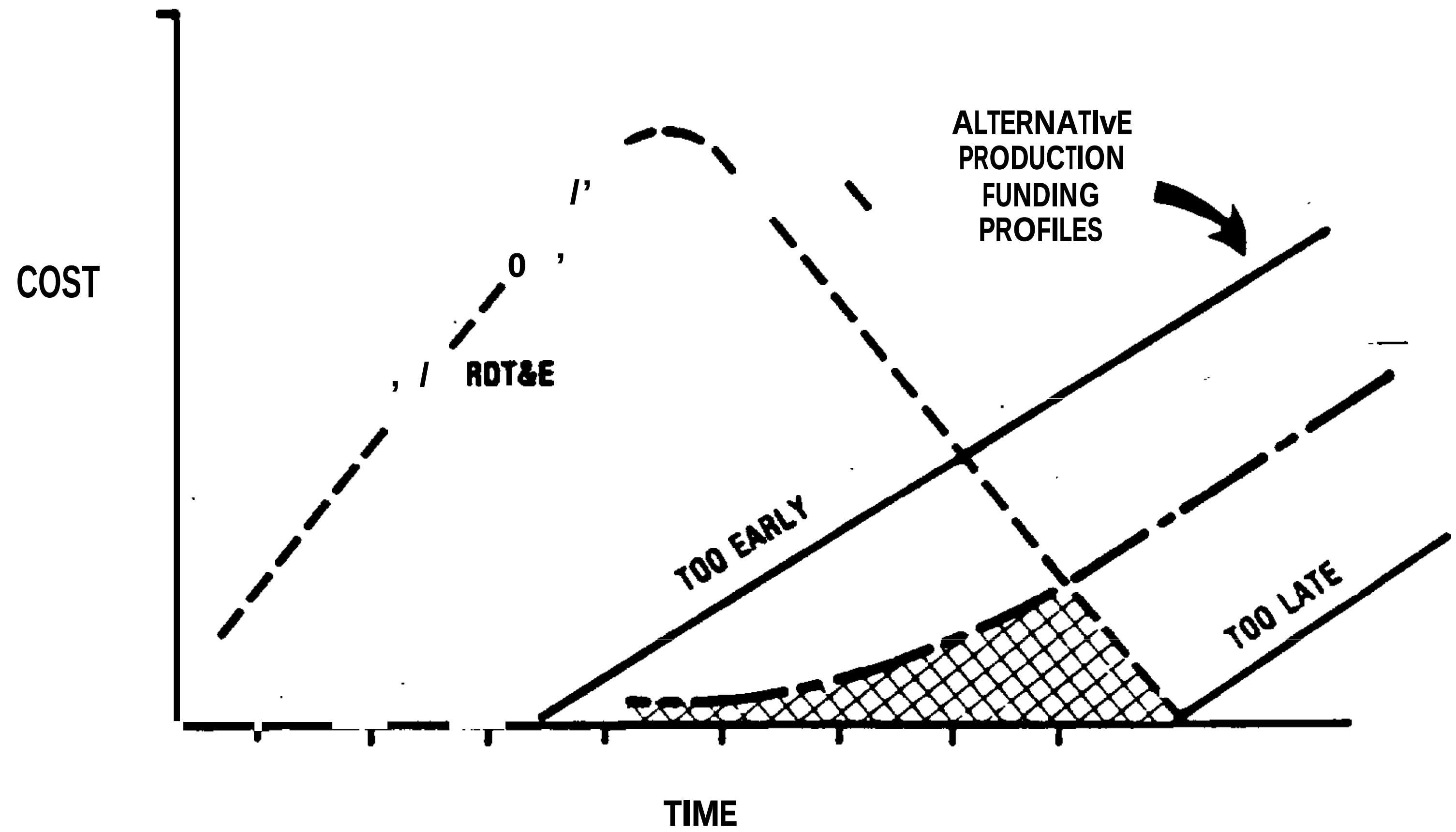
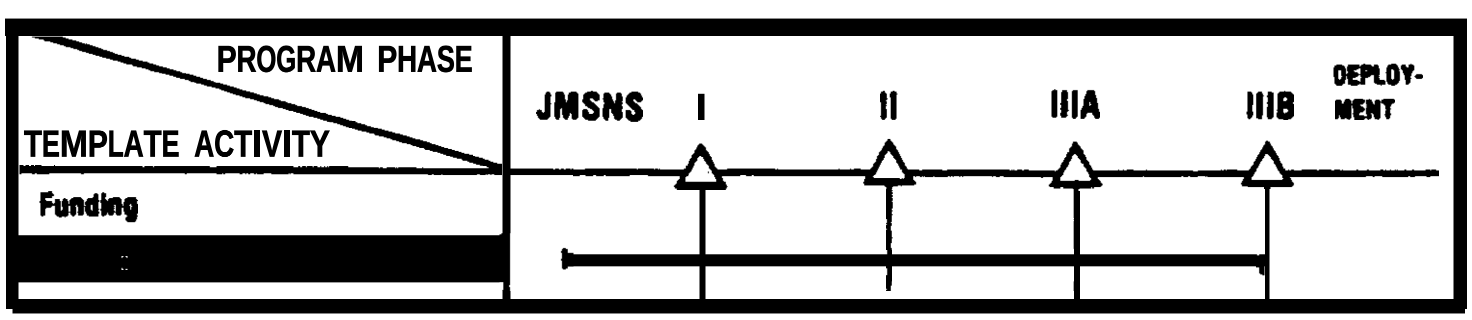



Figure 2-4. Funding Profiles (RDT&E and Production)

## TIMELINE




Early availability of enough funding from the RDT&E and procurement appropriations is essential for a smooth transition from development to production and early deployment. The proper focus must continue during each annual budget cycle. Without a proper funding profile, it will be impossible to keep the program in technical balance.

# CHAPTER 3

## INTRODUCTION FOR DESIGN CRITICAL PATH TEMPLATES

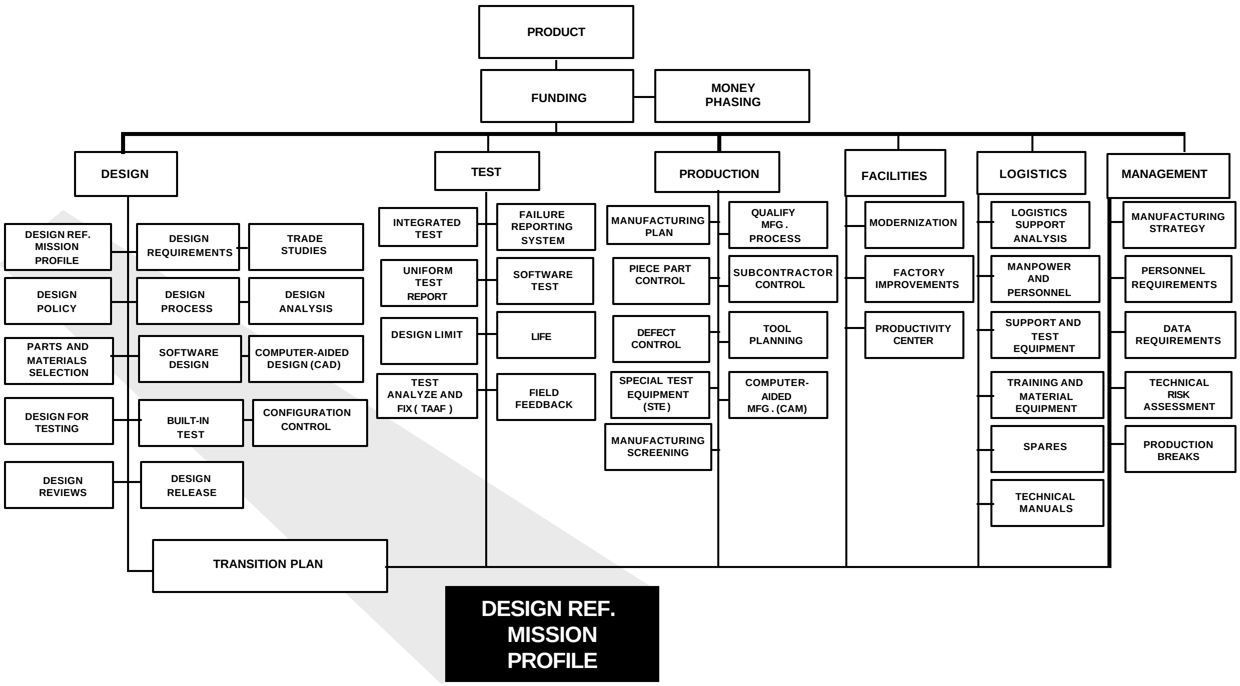
High risk of failure of Government material acquisition programs occurs at the outset of the design process. While some level of risk associated with a new technical concept may be unavoidable, historically this risk has been magnified by the misunderstanding of the industrial design disciplines necessary to turn the concept into a mature product. The Government and its contractors must share equal responsibility for this misunderstanding. The industrial proposal and Government source selection process provide the last cost-effective opportunity to ensure application of critical disciplines during design and therefore the ultimate achievement of design maturity. The application of these disciplines is the source of the requirement for "up front funding" to minimize material acquisition program risk.

What is design maturity? It is defined easily in the operational environment. A mature design meets operational requirements without additional Government or contractor intervention—no further field modifications or additional equipment and spares are required to overcome design shortfalls. In the factory, design maturity might be indicated by the tapering off of engineering change proposal (ECP) traffic, once the test phase is underway, if it can be assumed that contract requirements are being met. But what constitutes design maturity at the conclusion of the design effort before entering the formal test phase? This is the question faced at the critical design review (CDR), when a decision to proceed with fabrication of formal test articles must be made, a decision on which hangs this matter of risk.

Among the many engineering disciplines that must be applied to arrive at a product design are several, bearing directly on risk, that have been underemphasized by the Government and underutilized by its defense contractors. These disciplines share a common thread—all serve to reduce stress in the broadest sense. At the micro-level, parts age at a rate dependent on the stress they must endure. A design can be said to be mature when it meets its functional performance requirements and the applied stresses are well-known, and the ability of every part to endure those stresses can be ensured for the required life of the product. The engineering disciplines that determine stress and ensure the ability of the parts to endure stress are those that have received the least attention in defense system acquisition.

The templates in this section address those neglected engineering design disciplines. The Government and its contractors bear equal responsibility to address the issues in all material acquisition programs. The outlines for reducing risk will serve to guide the Government both in the preparation of requests for proposals and in proposal evaluation during source selection. They also will serve to guide program managers in the conduct of formal design reviews; and the outlines will serve notice to Government contractors of the unclaimed risk issues on which the Government intends to take action, as a guide to ordering their internal policies and procedures.

TEMPLATE




## AREA OF RISK

Accurate and complete specification of the design reference mission profile is required in order to support the entire acquisition process: design definition, stress analysis, test design, logistic support analysis, et. al. The degree to which the specified mission profile corresponds to ultimate service use directly determines the degree of risk. Conversely, this degree of correspondence also affects progress toward design maturity, which is ultimately decided by service use, not development and operational testing. Yet the mission profile is often left to the contractor’s discretion, based on a board definition of the Government’s intended use of the product.

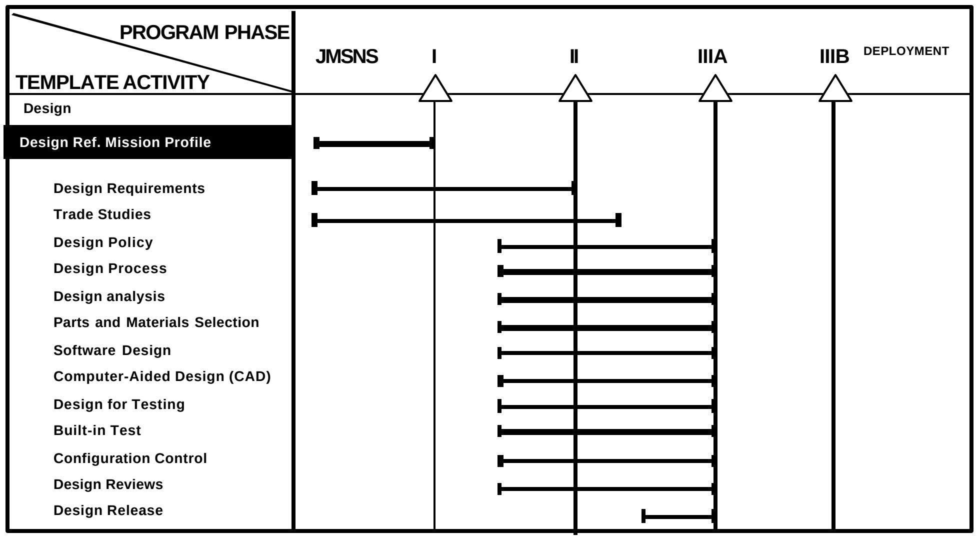
## OUTLINE FOR REDUCING RISK

- A functional mission profile is prepared that shows on a time scale all the functions that must be performed by the system to accomplish the mission. The functional mission profile of a system having multiple or variable missions is defined by a hypothetical design reference mission profile that contains a comprehensive listing of all functions expected in every potential mission.
- An environmental mission profile is prepared that shows on a time scale the significant properties of the surroundings (and their limits) that are likely to have an effect on the operation or survival of the system. It defines the total envelope of environments in which the weapon system must perform, including conditions of storage, maintenance, transportation, and operational use.
- Mission functional and environmental profiles are prepared by the Government and included in requests for proposals, forming a basis for proposals, source selection, and contracts.
- System functional and environmental profiles are prepared by the contractor on the basis of the total envelope of external environments given by the mission profile, to

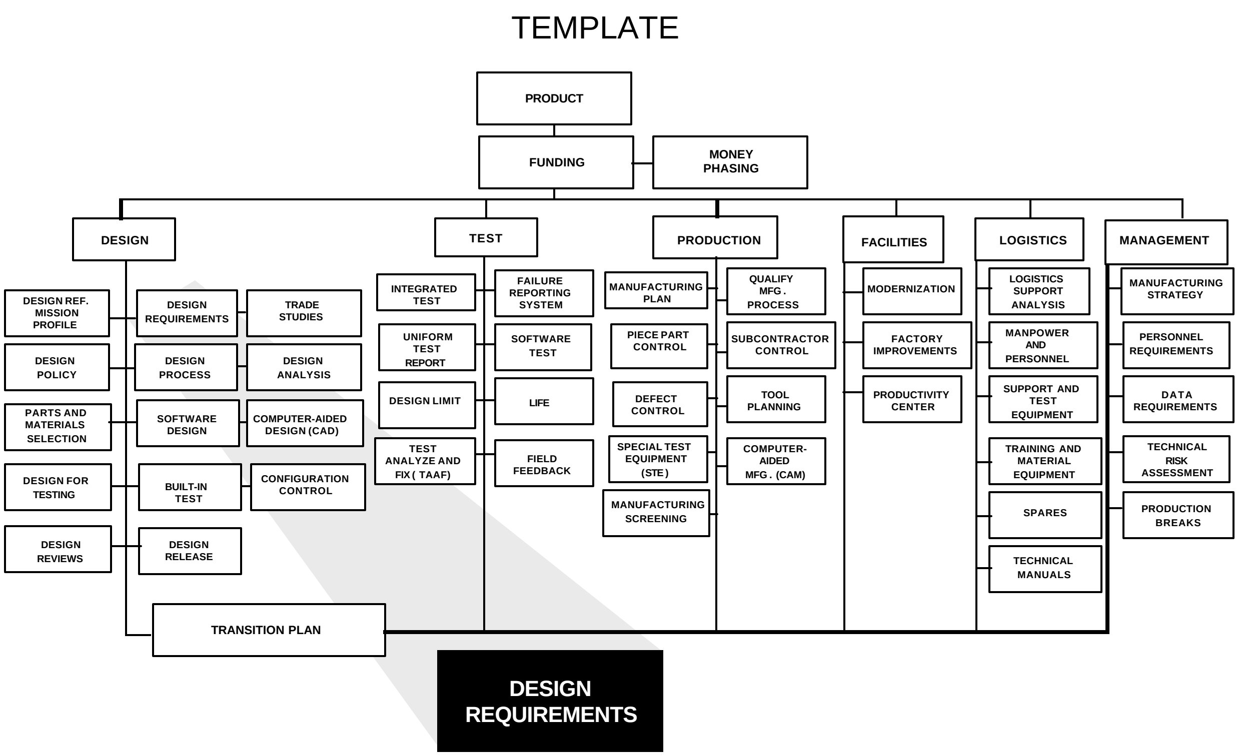
define the functional requirements and induced environmental conditions for the system and its component parts. These become the design requirements for the component parts of the system.

- The design requirements and concept should include a determination of support and operability factors such as the need to interoperate with other Military Service and allied systems.

## TIMELINE




System functional and environmental profiles are prepared by the contractor during the early stages of concept development.



## AREA OF RISK

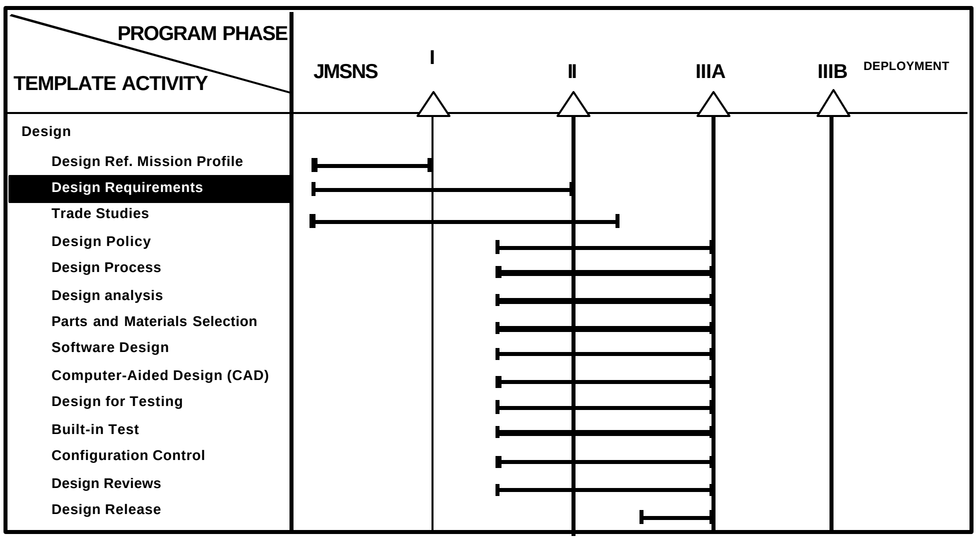
Design requirements are translated from operational requirements, stated by the "user" activity, and frequently negotiated or evolved during the course of design. They may include design requirements that are not measurable directly during the design process, but only can be verified by extended formal tests. Such intangible design requirements are a common cause of high risk.

## OUTLINE FOR REDUCING RISK

- Design requirements are developed in parallel with the development of the design reference mission profile. They are defined completely in the requests for proposals, in order that one basis for source selection may be the offeror's approach to satisfying those requirements, including Government evaluation of corporate design policy bearing on product risk. The complete design reference mission profile, including support-related "design to" requirements, is specified in these design requirements.
- Primary design requirements are stated in terms of parameters that can be measured during the design process, by breadboard testing or analogous design action. Probabilistic specifications that would require extended system level testing to verify compliance cannot be used by the design engineer for real time design decision making, and are therefore considered secondary, to be used for planning purposes only.

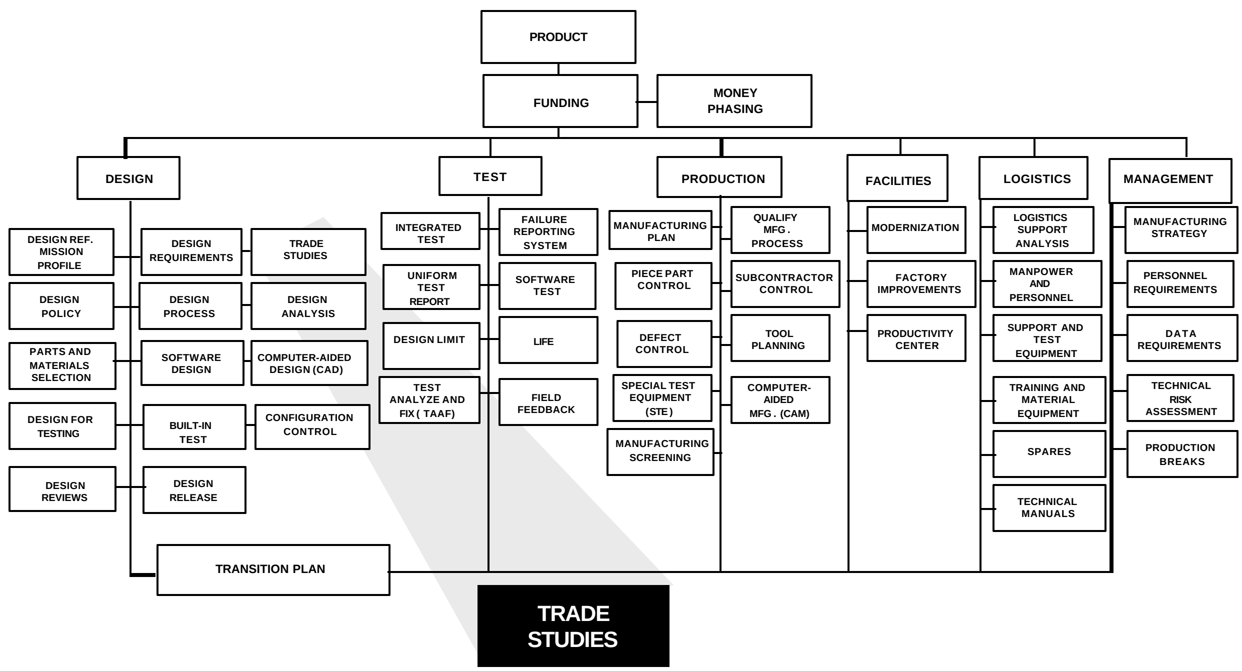
- When the achievement of specific quantitative system requirements is conditional upon the performance of a set of predefined tasks, the contract establishes the requirements for development of approved program plans for the accomplishment of these tasks. This will apply to such disciplines as structural analysis, weight control, reliability, maintainability, systems safety, survivability, corrosion prevention, parts standardization, and similar activities.
- Contractors are responsible for ensuring that subcontractors and suppliers have complete and definitive design requirements that flow down Government requirements such as measurable parameters and performance of predefined tasks.

## TIMELINE




Design requirements are established early in the conceptual phase and may be altered during validation as well as increased in level of detail and specificity. The design reference mission profile influences the design requirements for the component parts of the system. The contract for validation should be structured to require contractor recommendations for selection and tailoring of the optimum specifications and standards for application before the start of FSD.

TEMPLATE




## AREA OF RISK

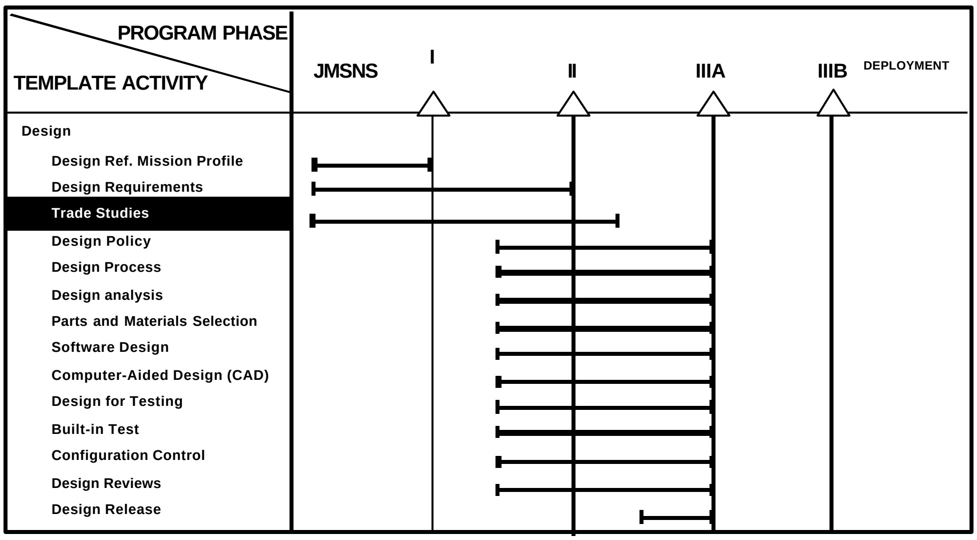
Trade studies are essential elements of material acquisition programs, not only in defining concepts that best meet mission needs, but also in fine-tuning selected concepts during the design process. Concept validation may not be complete at the beginning of full-scale development, however, there is the expectation that significant conceptual problems can be resolved during the design process. In addition, reducing production risk frequently is not a trade study criterion.

## OUTLINE FOR REDUCING RISK

- Concepts representing new technology untested in the production environment are validated fully before FSD.
- Trade studies during the design process are oriented towards reducing product risk, by such means as design simplification, design for compatibility with production processes, design for ease of both factory testing and built-in test, and design for supportability and readiness.
- Early in the design phase, full consideration is given to standard components that have been developed and can meet the mission requirements (such as standard avionics, egress seats, etc.).
- A quantitative trade parameters list is developed and standardized across all design, manufacturing, and quality disciplines as a priority task early in the RDT&E program.

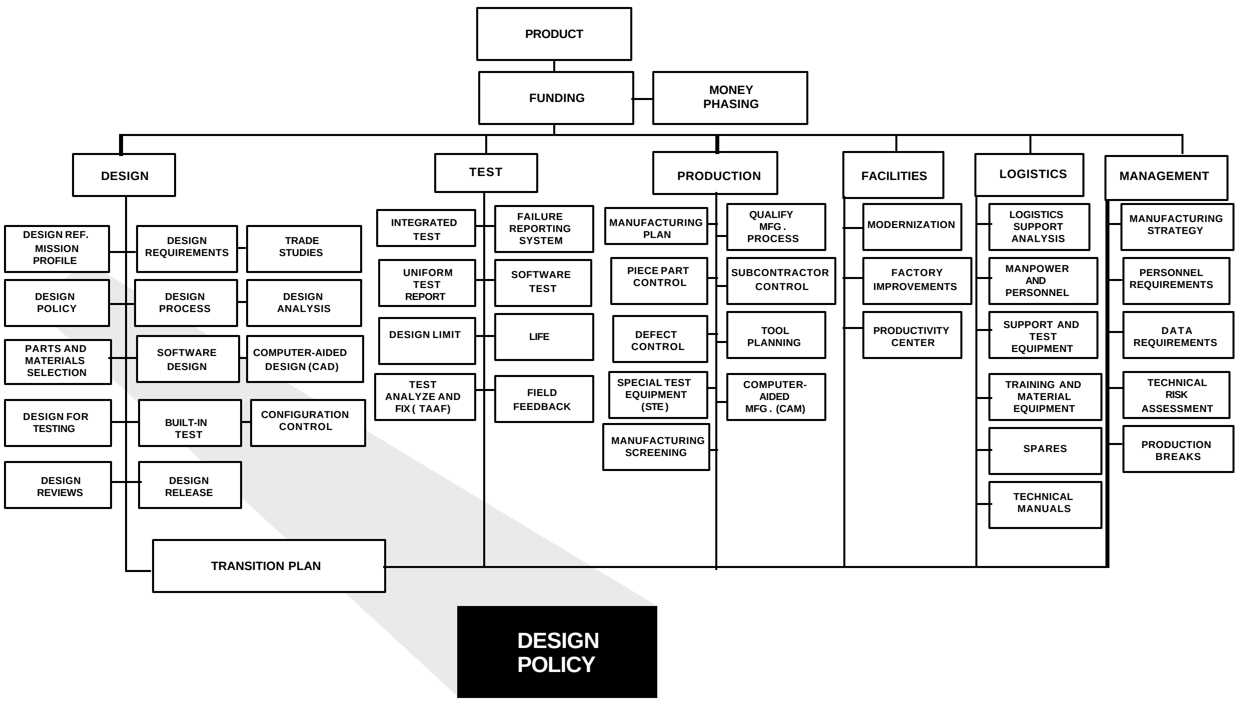
- Trade study alternatives are documented and preserved formally in design review documentation to ensure system engineering traceability to design characteristics downstream.
- Production transition trade studies are based on design and performance criteria as weight factors for trade study decisions.
- Product quality and reliability are not trade study parameters to be sacrificed for cost, schedule, or performance gains.

**TIMELINE**




A broad spectrum of trade studies is initiated during the concept exploration phase. These trade studies continue on into FSD as a logical approach to selecting the best design once the mission profile and design requirements have been specified. The final selection and fine turning of the design approach must consider such factors as producibility and operational suitability as well as performance, cost, and schedule.

TEMPLATE




## AREA OF RISK

The implementation of the engineering design disciplines involved in reducing product risk is the responsibility of Government contractors. The existence or absence of documented corporate policies, backed up by controlled engineering manuals to the necessary degree of detail, has a direct bearing on the degree of product risk associated with material acquisition. Many Government contractors do not have such corporate policies, and when these policies do exist, they often lack implementation at the operating level and often lack substantive direction on design for low risk.

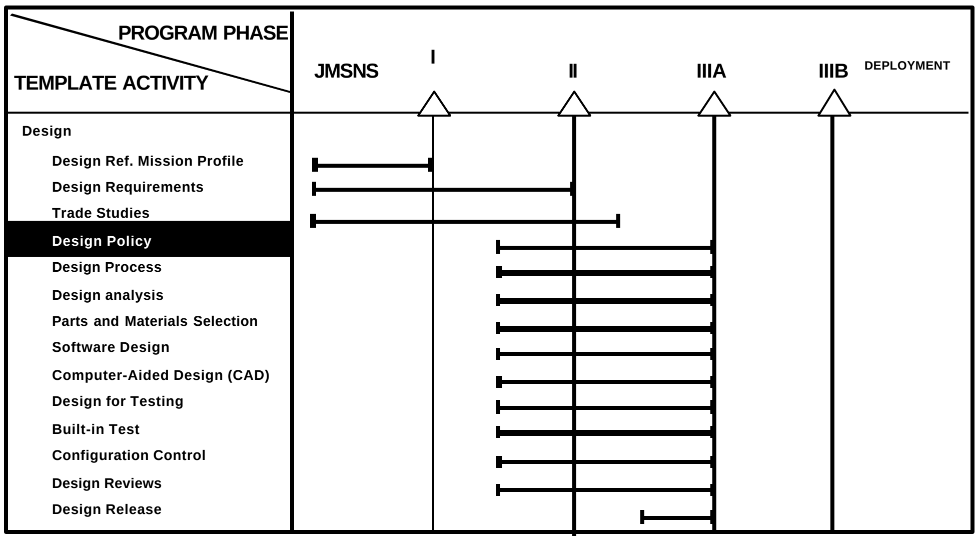
## OUTLINE FOR REDUCING RISK

- Documented design policies and comprehensive engineering documents implementing these policies are visible and adhered to in design, test, and manufacturing practices.
  - Policies and practices are sensitive to “lessons learned” on past programs.
  - Abundant evidence is available that engineering practices are tailored to product lines.
  - Policies and practices reflect the importance of designing for supportability as an integral part of all design efforts.
- Engineering design has the documented responsibility not only for development of a low risk design but also for specification of test requirements and design for production and support.
- Engineering practices in the form of criteria and standards are included in an integrated data base accessible by design, test, production, and logistics engineering personnel.
- Established design review criteria are available and are used by an expert design review team. These criteria, along with specific means of assessing maturity, are tailored

specifically to product lines.

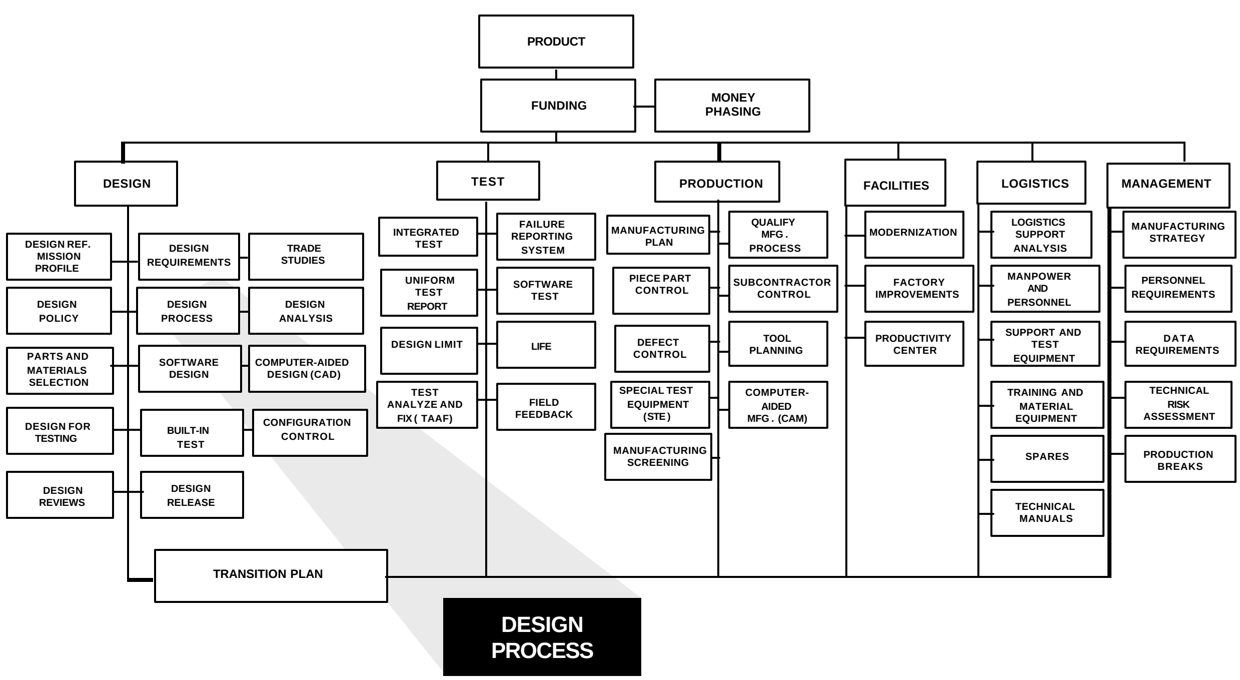
- Design emphasis is placed on implementation of design fundamentals, disciplines, and practices that are known to produce a low risk design and that ensure design maturity before design release.

## TIMELINE




The implementation of best practices in engineering design is the responsibility of contractors. The existence or absence of documented corporate policy has a direct bearing on the degree of product risk associated with material acquisition. Appropriate design policies are developed and proven before FSD, and they may be updated and otherwise refined as experience is gained during development.

TEMPLATE



## AREA OF RISK

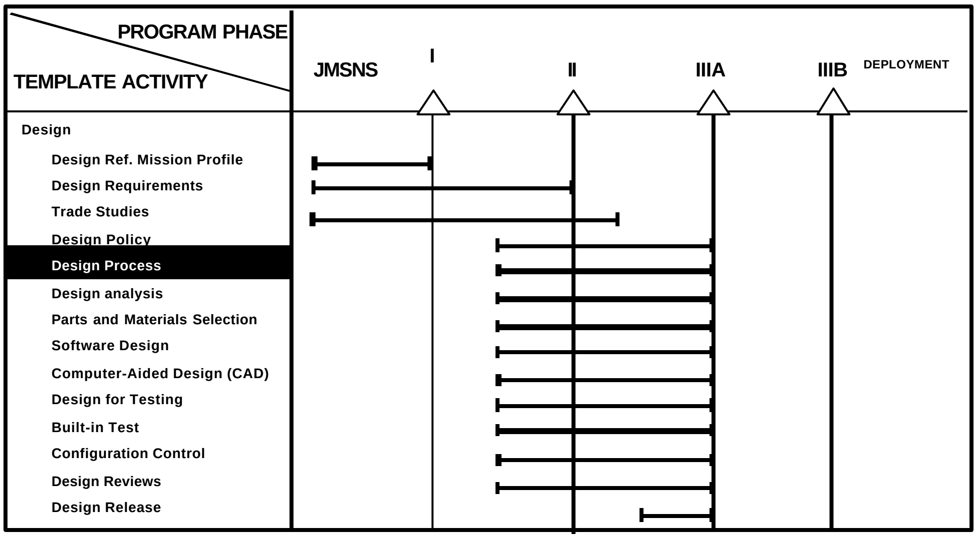
The design process ought to reflect a sound design policy and proper engineering disciplines and practices—an integration of factors that influence the production, operations, and support of a system throughout its life cycle. Nevertheless, concepts are often selected, demonstrated, and validated with little thought given to the feasibility of producing a system employing those concepts. This omission is then carried forward into design, with voids appearing in manufacturing technology and absence of proven manufacturing methods and processes to produce the system within affordable cost. One of the most common sources of risk in the transition from development to production is failure to design for production. Some design engineers do not consider in their design the limitations in manufacturing personnel and processes. The predictable result is that an apparently successful design, assembled by engineers and highly skilled model shop technicians, goes to pieces in the factory environment when subjected to rate production. A design should not be produced if it cannot survive rate production without degradation.

## OUTLINE FOR REDUCING RISK

- The potential to produce a system is investigated carefully during the demonstration and validation phase by means of appropriate producibility analyses. Voids in manufacturing technology projects and manufacturing methods and processes peculiar to the design of the specific system, subsystems, and components are addressed during engineering development. These methods and processes are proven by pilot lines and pilot quantities, when necessary.

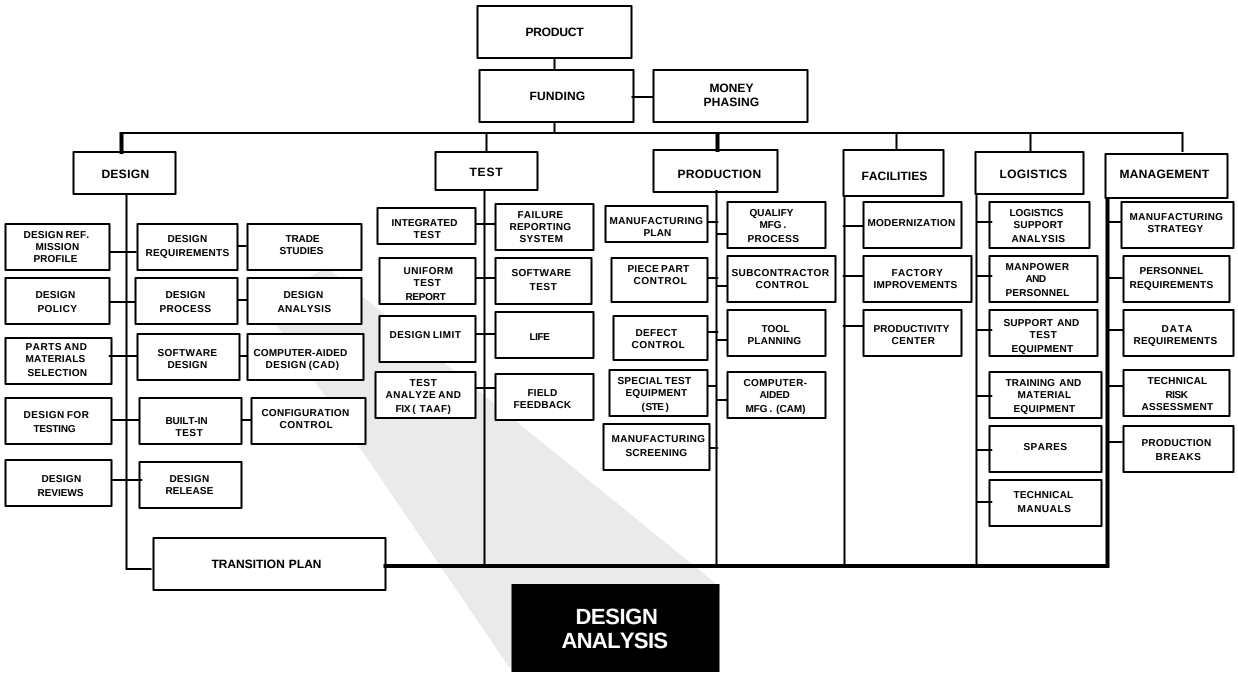
- The design avoids reliance on a single unproven manufacturing technology for system critical performance characteristics. Alternative technologies and design approaches are carried through Milestone II and into engineering development, when warranted.
- Producibility engineering and planning is an integral element of the design process. Close coordination between production and design engineering is established from the outset. Integration of life cycle factors in the design is fostered by forming design teams with production engineering and support area representatives. Manufacturing coordination is part of production drawing release. Production engineers participate in design concept development and design engineers participate in production planning to ensure design compatibility with production.
- The design process specifically ensures both performance and producibility considerations for packaging of electronic components. Factors such as envelope clearance, package density, predicted versus actual weight, tooling, and power access are equally as important as component and circuit design considerations in reducing transition and production risk.
- The design is evaluated to ensure that the producibility and supportability factors are being incorporated. Producibility and supportability design changes are expedited and incorporated as early as possible to reduce cost and are not resisted automatically. These changes are substantiated promptly by necessary testing.
- A task analysis approach, as called out in Military Handbook 46855B (reference (c)), is used to divide tasks among hardware, software, and operators. System design then proceeds with this partitioning in mind, thus reducing the risk of complex tasks being "dumped" on operators when they are better performed by software. This partitioning also helps to bound and define the entire design effort.
- Cross training of engineers in design and manufacturing disciplines actively is supported. Design engineers stay abreast of developments in manufacturing technology that would affect the design.

**TIMELINE**




The design process describes all the actions taken that culminate in a set of drawings or a data base from which a model can be constructed for testing to verify specification compliance. Design criteria are developed and proven before FSD, and may be updated and otherwise refined as experience is gained during development. Production design occurs concurrently with the other elements of the design process. Much useful information guidance technology on obtaining a producible design is in Military Handbook 727 (reference (d)).

TEMPLATE




## AREA OF RISK

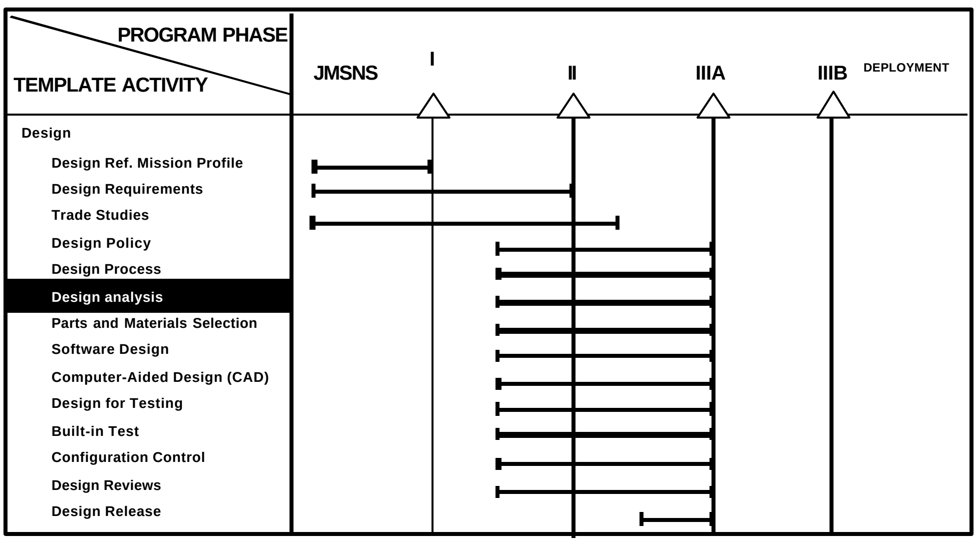
Engineering design involves many specialized analyses, most of which are oriented towards meeting desired performance specifications. There also are specialized analyses oriented towards proofing design risk but they are not practiced widely. When they are completed, it is often by personnel other than the design engineers most familiar with the product design. These analyses are critical to ensuring a low risk design.

## OUTLINE FOR REDUCING RISK

- Stress and stress/strength analyses are performed to ensure that applied values of all parameters specified in the derating, margin of safety, and safety factor criteria for all component parts and materials meet those criteria.
- "Worst case" tolerance analyses are performed to ensure that the system design performance remains within specified limits for any combination of component part parameters within the limits of their own allowable tolerances.
- Sneak circuit analyses are performed to detect such unexpected failure modes as latent circuit paths, timing errors, or obscure "cause and effect" relations that may trigger unintended actions or block desired ones without any part failures having occurred.
- Failure modes and effects analyses are performed in order to understand the effect of each component part failure on overall design performance, and system and equipment supportability. Each component part is analyzed for the purpose of reducing these effects to a minimum through design changes.

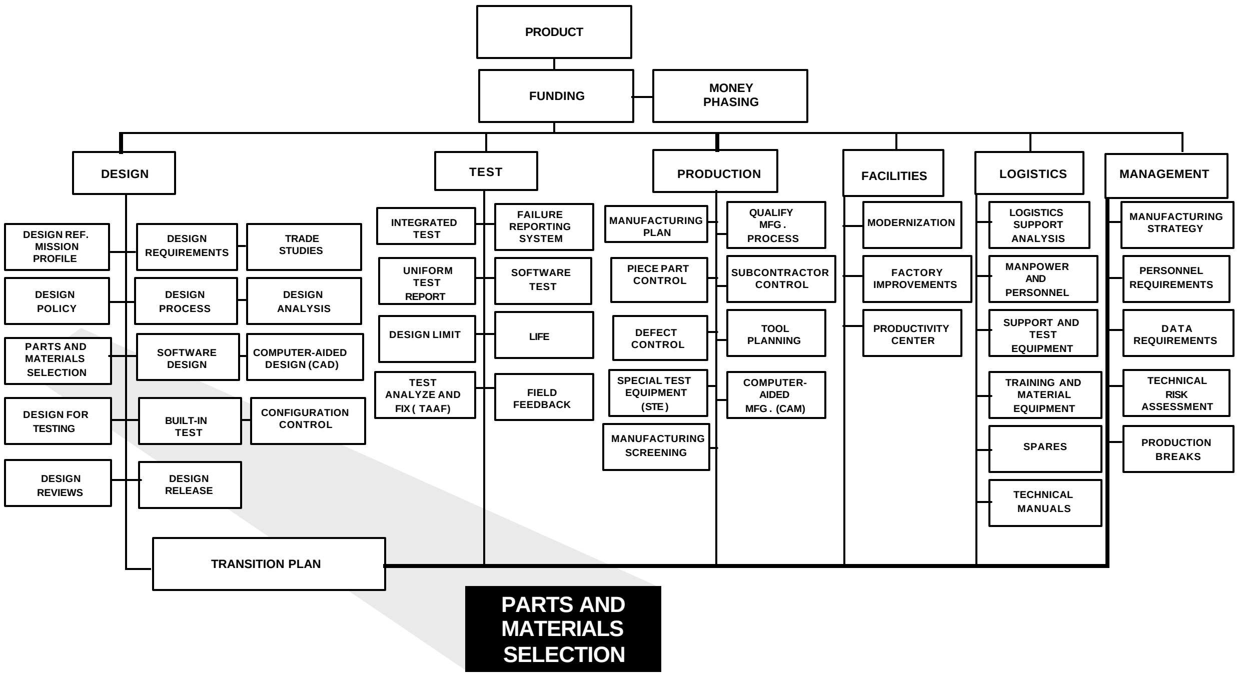
- A thermal survey is conducted on electronic systems to validate the accuracy of the thermal stress analysis, which is then revised as indicated by the survey to yield more accurate results.
- Other analyses that may be applied effectively are fault tree, mass property, system safety, maintainability, life cycle cost, fault isolation, redundancy management, and vibration survey.
- The results of these analyses are used to revise the design, as necessary, to reduce design risk, and the analyses are update, as necessary, for changes in design. Design risk analyses are not performed simply for the sake of meeting contract data requirements.
- CAD techniques are developed or acquired, as necessary, to conduct these analyses to the maximum extent possible, both as a potential savings in engineering time and cost, and in the interest of improved and more consistent analytical accuracy.
- Integrated logistics support analyses are performed to understand and determine the effects of a design on supportability and logistics resources requirements for the purpose of reducing any adverse effects.

## TIMELINE




Design analysis policies are developed and proven before FSD, but shall be updated and otherwise refined as experience is gained during development. Their use is completed largely, except for engineering changes to correct failures, at the conclusion of the design process.

TEMPLATE




## AREA OF RISK

Low risk designs allow parts and materials to operate well below their maximum allowable stress levels. Performance-oriented military programs often attempt to use these same parts and materials at much higher stress levels. Pursuit of interoperability and parts standardization also may introduce similar risks. These choices often are made by using mathematical models and generic handbook data that are imprecise. The resultant high risk may not be discovered except by testing, often operational testing, which is too late to avoid extensive corrective action.

## OUTLINE FOR REDUCING RISK

- The following design criteria are used for part operating temperatures (except semiconductors and integrated circuits). These criteria apply to case and hotspot temperatures.

| | |
|---|---|
| ≤ 3 watts: | $40^0$C rise from the part ambient with a maximum absolute temperature of $+110^0$C |
| > 3 watts: | $55^0$C rise from the part ambient with a maximum absolute temperature of $+125^0$C |
| Transformers: | $30^0$C rise from the part ambient with a maximum absolute temperature of $+100^0$C for MIL-T-27 class S insulation |
| Capacitors: | $10^0$C rise from the part ambient with a maximum absolute temperature of $+85^0$C |

Of all the forms of stress to which electronic parts are susceptible, thermal stress is the most common source of failures. The thermal stress guidelines that are highlighted have been instrumental in reducing the failure rate of electronic equipment by up to a factor of 10 over traditional handbook design criteria.

- The junction temperatures of semiconductors and integrated circuits normally should not exceed +110$^0$C, regardless of power rating. The failure rates of semiconductors decrease by as much as a factor of two for each 10$^0$C by which their junction temperatures can be lowered. In modern electronic systems having high semiconductor populations, this translates to an approximately equal decrease in the overall system failure rate when instituted as design policy. In one program involving 200 aircraft, each 5$^0$C reduction in cooling air temperature was estimated to save $10 million in electronic system maintenance costs by reducing failure rates.

- The absolute values of operating temperatures for all electronic parts in a design are determined both by analysis and by measurement.

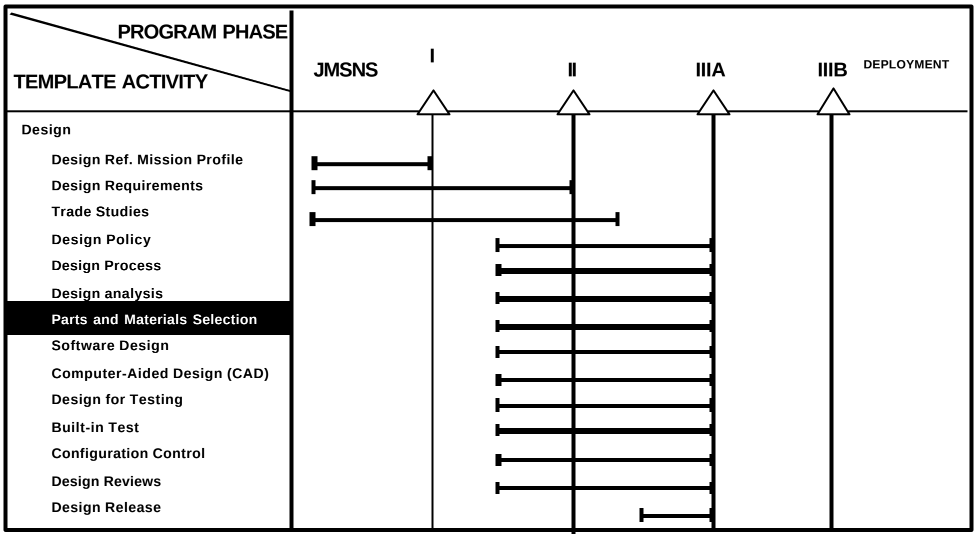
  Equipment used to perform thermal surveys on electronic systems and components now is available readily. This equipment usually is based on infrared scanning techniques, and now is capable of measuring even the junction temperatures of integrated circuits under development.

- Government contractors include in their design policies and their parts and materials programs the derating criteria for all classes of parts and materials to be used in their products, specifying absolute limits on all parameters to which reliability is sensitive. This policy is subject to review and approval by the Government before contract award.

  Stress derating practice ranks with mission profiles as the most critical design factors associated with low risk products.

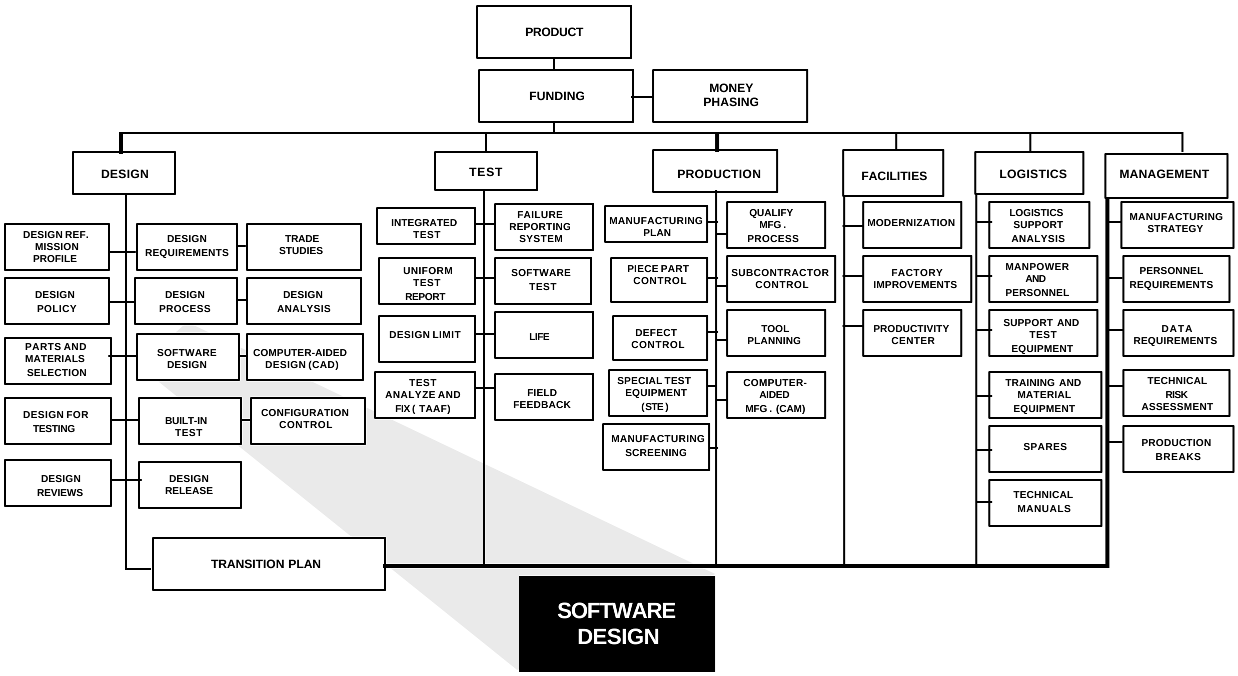
- Program-peculiar approved parts lists (APL), in general a sub-set of the Military Specification (MIL-SPEC) lists, are issued at the start of FSD. The APL shall inform all designers of the program's standardization decisions—on resistors, capacitors, other electronic parts, fasteners, connectors, wire, epoxies, and so forth. Designers must use the selected standard parts when they meet system requirements or justify use of nonstandard parts.

## TIMELINE




Parts and materials selection and stress derating policies must be in place at the start of hardware development. The contractor design review process is the primary mechanism to ensure compliance with these policies.

TEMPLATE




## AREA OF RISK

Many weapon systems now depend upon software for their operations and maintenance. Whether the software is embedded (“tactical” or “firmware”) or loaded into main memory from peripheral storage devices, the problems are the same—the weapon systems cannot be qualification tested and they can’t function, in most cases, without proper software. A software error can cause a weapon system failure. Nevertheless, software frequently fails to receive the same degree of discipline as hardware early in FSD. Failure to allocate system requirements clearly between hardware and software greatly increases the difficulty of isolating and correcting design problems. Industry experience shows that 64 percent of all software errors are traceable to functional or logical design, with the remaining 36 percent due to coding.

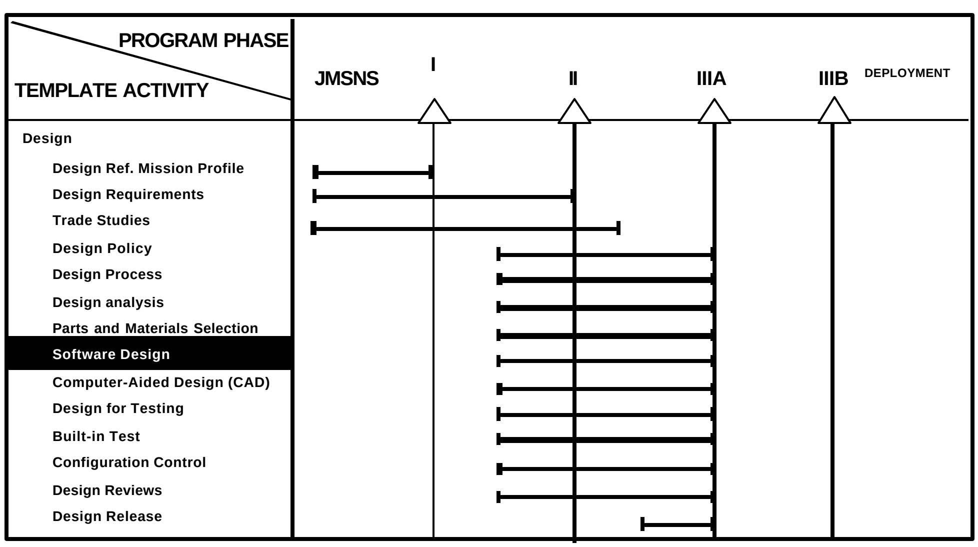
## OUTLINE FOR REDUCING RISK

- The applicability to software in the outline for reducing risk of every design template is considered. Most templates are as applicable to software as to hardware, especially design process and design analysis.
- Functional requirements are allocated either to hardware or to software, as appropriate, at design start. These allocations usually are trade study topics, since it often is not clear initially which functions should be implemented in hardware, and which in software. Hardware and software responsibilities reside with one individual.
- Proven design policies, processes, and analyses governing software design are employed, including, but not limited to the following:
  – Rigorous configuration control.

– Chief programmer/designer teams and modular construction.
– Structured programming and top-down design.
– Structured walkthroughs.
– Good documentation.
– Traceability of all design and programming steps back to top level requirements.
– Independent review of requirements analyses and design process.
– Thorough test plan developed and utilized from design start.
– Compliance with standards.
– Structured flowcharting.

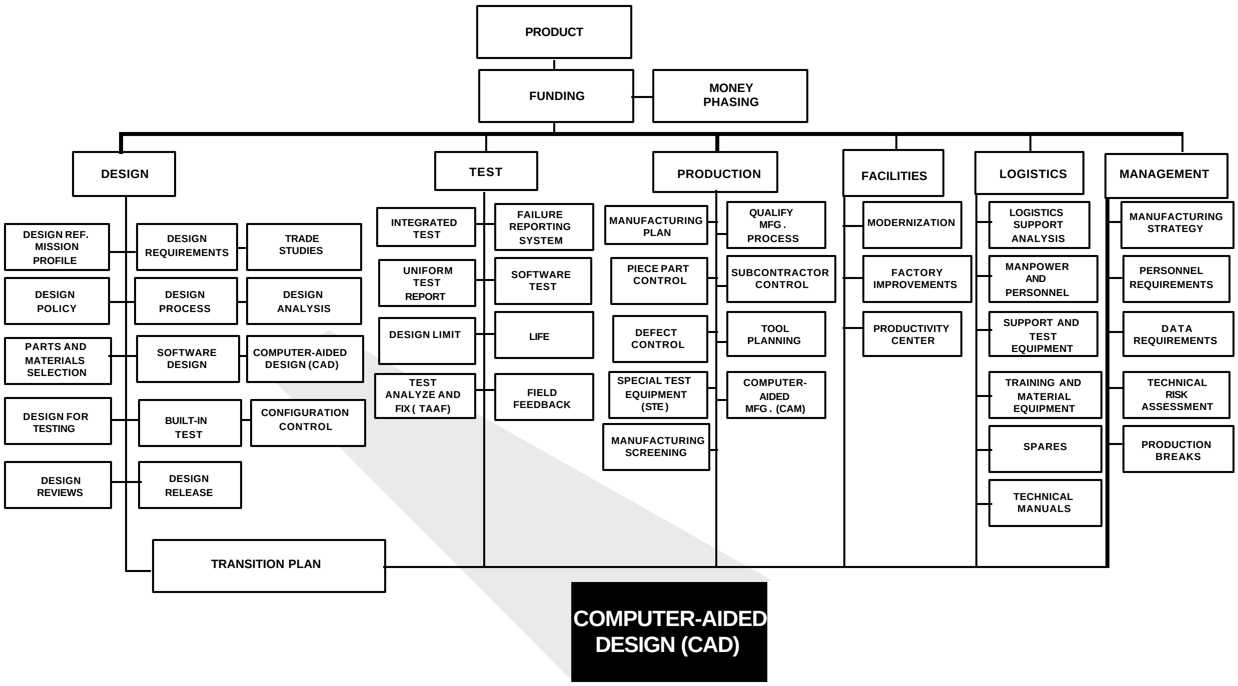
- Computer software developers are accountable for their work quality, and are subject to both incentives and penalties during all phases of the system life cycle.
- A uniform computer software error data collection and analysis capability is established to provide insights into reliability problems, leading to clear definitions and measures of computer software reliability.
- A software simulator is developed and maintained to test and maintain software before, during and after field testing.
- Security requirements are considered during the software design process.

## TIMELINE




It is essential that software design practices follow a disciplined process similar to proven hardware design practices. Design schedule for software coincide with the hardware schedule.

TEMPLATE




## AREA OF RISK

Many design tools and analysis techniques required to achieve a mature design are not used or performed at all because they are time consuming and costly. Engineers don't always follow the design rules that their companies require. Producibility and testability of the design is often lacking due to lack of communications with and knowledge of manufacturing processes. Obtaining a good understanding of the design before it is built and tested is often lacking, increasing the length and cost of test and fix periods, increasing cost of redesigning tooling and test equipment, and increasing support costs and the risk during the transition to production and early deployment. Obtaining information on part and material parameter limitations and availability, as technology produces new items, is time consuming when available only in printed form.

## OUTLINE FOR REDUCING RISK

- Computer-aided design (CAD) is carried out in the factory as part of a thorough modernization strategy.
- Each design engineer is provided the use of an alphanumeric computer terminal.
- An interactive graphics terminal is provided for each group of four to six design engineers.
- These graphics terminals have user-friendly access to a data base that contains the following:
  - Parts and materials data.
  - Design rules (both corporate policy and product specified).
  - Design specifications (mission profile, performance and reliability requirements,

supportability design-to requirements, limits, and boundaries).

– Manufacturing rules (special processes, testability, and estimated quantity).

– File and retrieve capability, including design data and analysis results.

- Terminals have user-friendly access to special computer software (programs) that provide a capability to accomplish the following:

  – Perform modeling and prototyping.

  – Perform simulation and performance analyses.

  – Perform special analyses such as the following:

    - Electrical stress.
    - Thermal stress.
    - Vibration stress.
    - Sneak circuit.
    - Failure modes and effects.
    - "Worst case" tolerance.
    - Reliability prediction and allocation.

  – Maintain configuration and design release control.

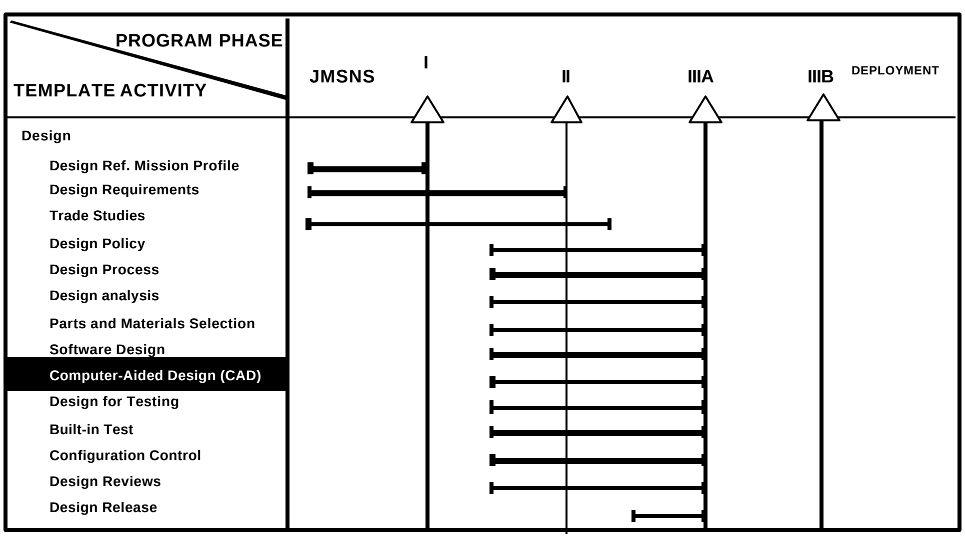
  – Help design product tests.

  – Manage test and failure analysis data.

- A common data base is in place to integrate CAD and computer-aided manufacturing (CAM) functions (see template on CAM) to achieve significant cost, schedule, quality, supportability, and performance benefits.

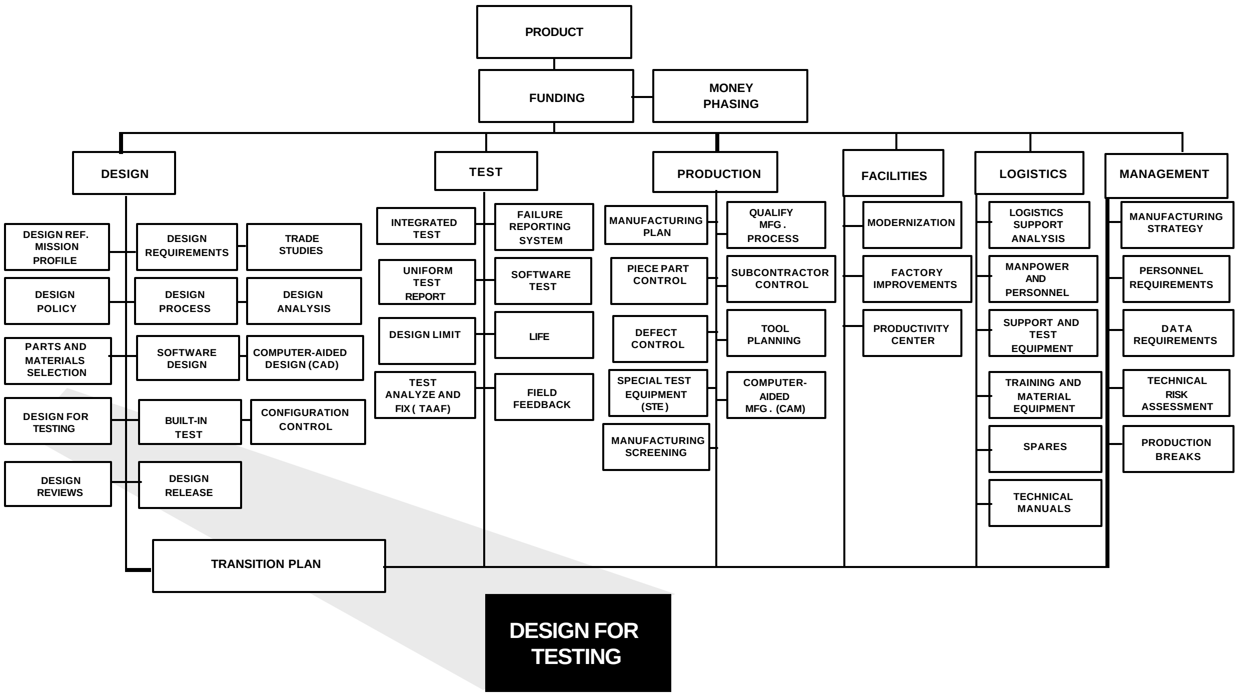
- An aggressive employee retraining program is in place to provide for orderly introduction of new skills.

**TIME LINE**




Through the use of CAD equipment, a full complement of design tools is available to facilitate the design process and satisfy producibility objectives.

TEMPLATE



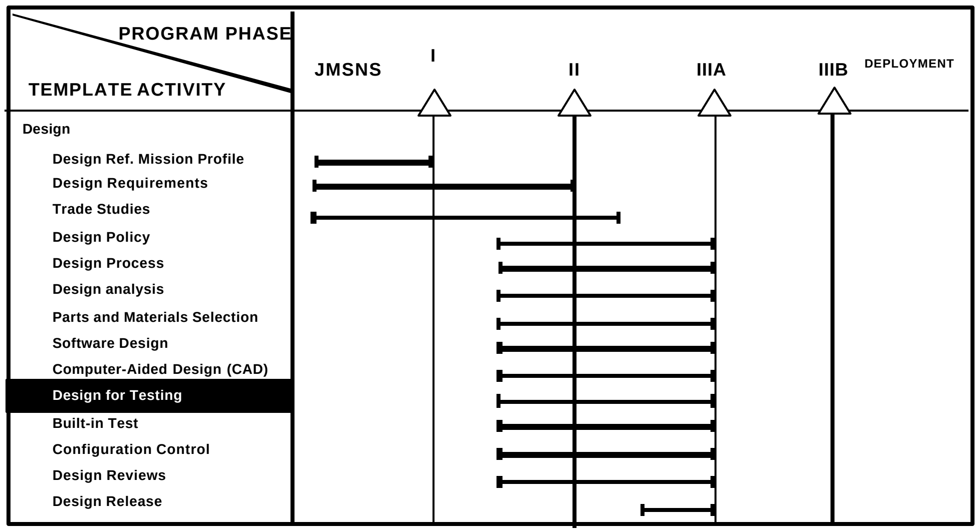

## AREA OF RISK

Test and inspection are integral functions of the production and operational environment. To survive the production process without degradation, a design must allow for access by both inspectors and various types of automatic testing approaches.

## OUTLINE FOR REDUCING RISK

- Design criteria are provided for partitioning, initialization, functional compatibility with automatic test equipment (ATE), functional coverage, modularization, and visual and physical accessibility.
- Trade studies are conducted for integrated application of built-in test (BIT), ATE, and manual testing to support fault detection and isolation.
- Production design studies are conducted to define inspection, test, and evaluation requirements; to maximize inspectability; and to minimize the need for special manufacturing tests and special factory or field test equipment.
- Classification of characteristics are noted on drawings.
- Test and evaluation (T&E) are planned and coordinated to minimize the need for subjective interpretation of a system's performance design requirements.
- Factory test consumes no more than 10 percent of expected product life.
- System level functional testing is conducted at a level that meets but does not exceed operational use requirements.

## TIMELINE




To provide for efficient and economical manufacture, consideration must be given to providing the proper test and inspection capabilities in the basic equipment design. Policies governing design for testing are established before FSD, and such design is completed largely at the conclusion of the design process.

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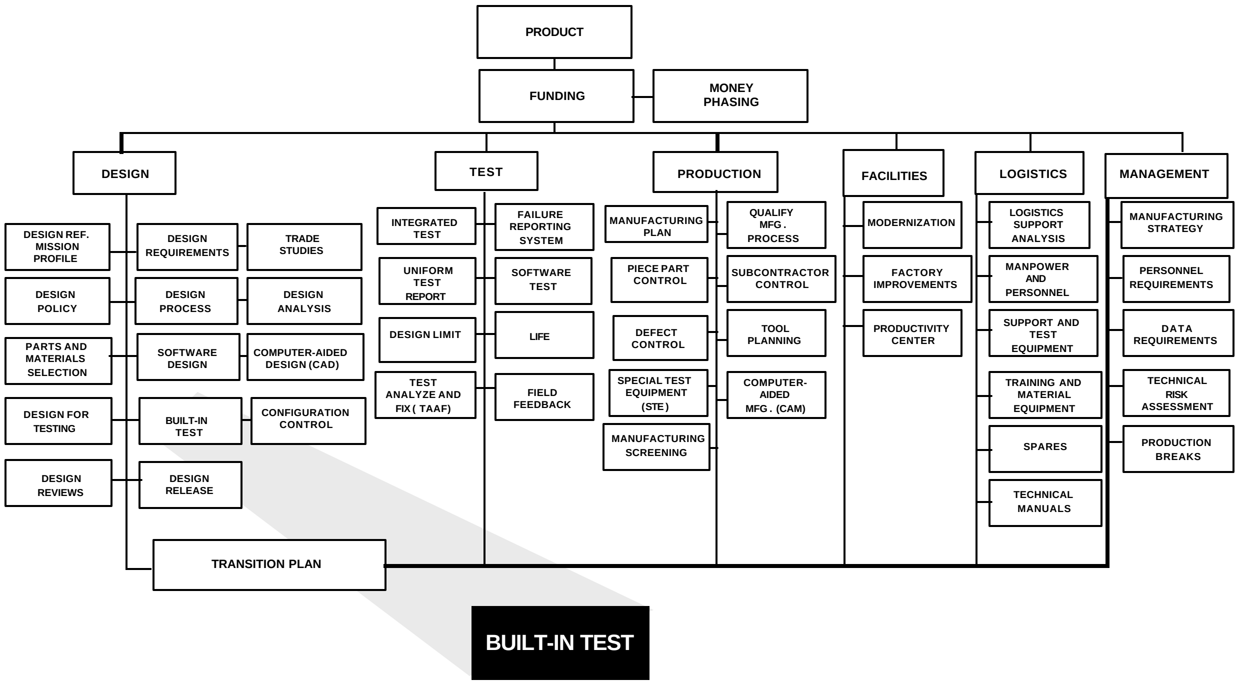


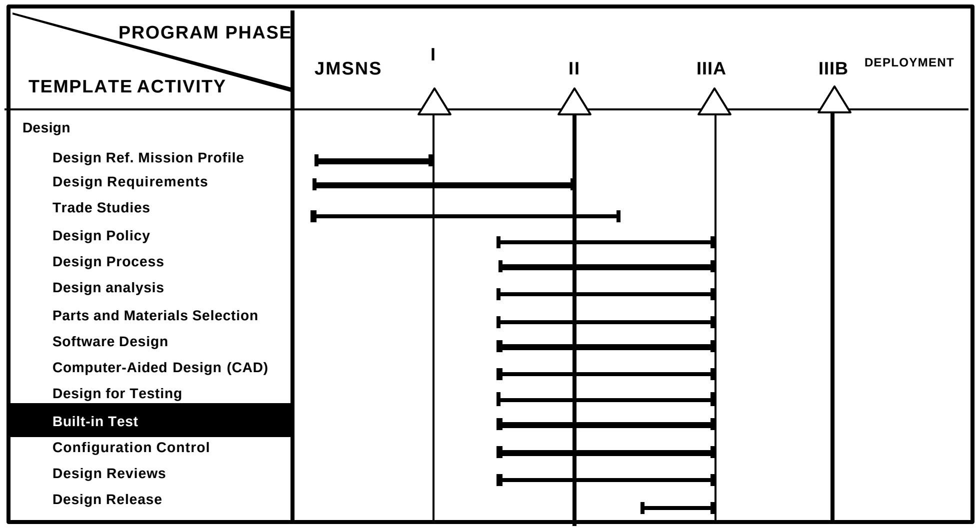

## AREA OF RISK

Built-in test (BIT) circuitry offers not only ease of maintenance in the field but also more rapid troubleshooting during factory test and production. Many designs do not include sufficient BIT capability to isolate failures to the single faulty line-replaceable or weapon-replaceable assembly, much less the shop-replaceable assembly or component part. One of the more common results is the line removal of functional assemblies along with the nonfunctional one, increasing downtime and causing unnecessary backlogs in logistic support. The argument is heard frequently that additional BIT equipment itself adds to product risk beyond the value it might have in maintenance. This argument may have had validity in an earlier era, but not with today’s complex yet low risk integrated circuitry.

## OUTLINE FOR REDUCING RISK

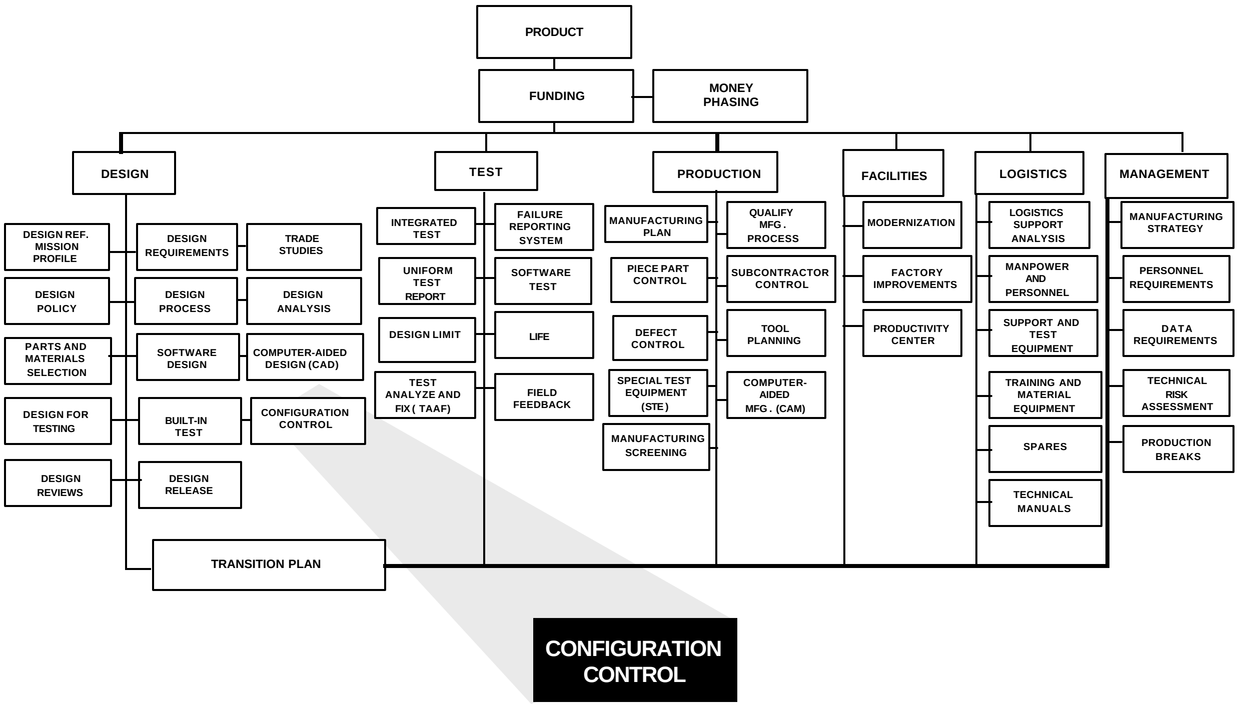
- Maintenance and support requirements are defined before initiation of BIT design.
- Design criteria are provided for the contribution of BIT circuitry to product risk, weight, volume, and power consumption. These criteria are established by Milestone II.
- Trade studies are conducted for each maintenance level on the interaction of BIT, automatic test equipment, and manual test in support of fault detection and isolation; and to optimize BIT allocation in hardware, software, and firmware.
- Production design studies are conducted to define the use of BIT in manufacturing inspection, test, and evaluation.
- BIT criteria, at a minimum, detect all mission compromising failures, and validate all redundant functions.

## TIMELINE




BIT is a significant factor in the initial design planning and tradeoff analyses and must be evaluated in subsequent design reviews. Concepts for BIT that are validated during the normal program validation phase may be adopted for the final design. BIT design is completed and validated during full-scale development.

TEMPLATE




## AREA OF RISK

A common source of risk in the transition from development into production is failure to establish and maintain a strong configuration control system. Direct application of boilerplate policies and/or invoking MIL-SPECs leads to ineffective control or overly complex and costly approaches to managing configuration. In a loosely implemented control system, design changes can occur without proper maintenance of the configuration change documentation after the design freeze is established. Lack of a good configuration control system leads to many pitfalls, including an unknown design baseline, excessive production rework, poor spares effort, stock purging rather than stock control, and an inability to resolve field problems. Poor configuration control is a leading cause of increasing program costs and lengthening procurement schedules.

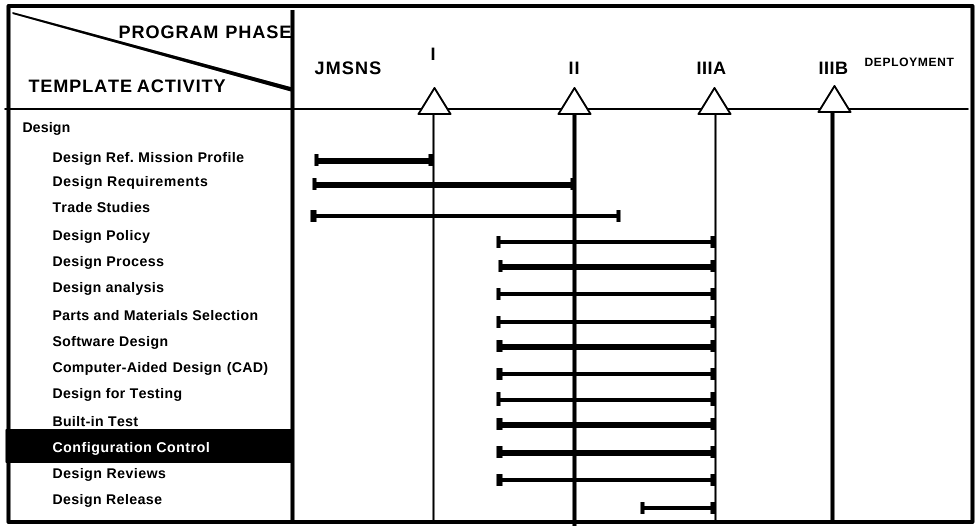
## OUTLINE FOR REDUCING RISK

- An effective configuration control system contains the following features:
  - It is tailored from an effective set of guidelines and standards to fit the nature of the program including hardware and logistics support elements.
  - Corporate or division policy recognizes the importance of proper configuration management in the development of a new program, and emphasizes the need to generate an adequate plan for implementation.
  - A configuration management plan is streamlined, yet adequately encompasses the entire life cycle of the program, recognizing the requirements of each phase of the life cycle and the complexity of the system configuration.

- The configuration management plan establishes the mode of operation and interface relationship among vendors, subcontractors, contractor, and customer.

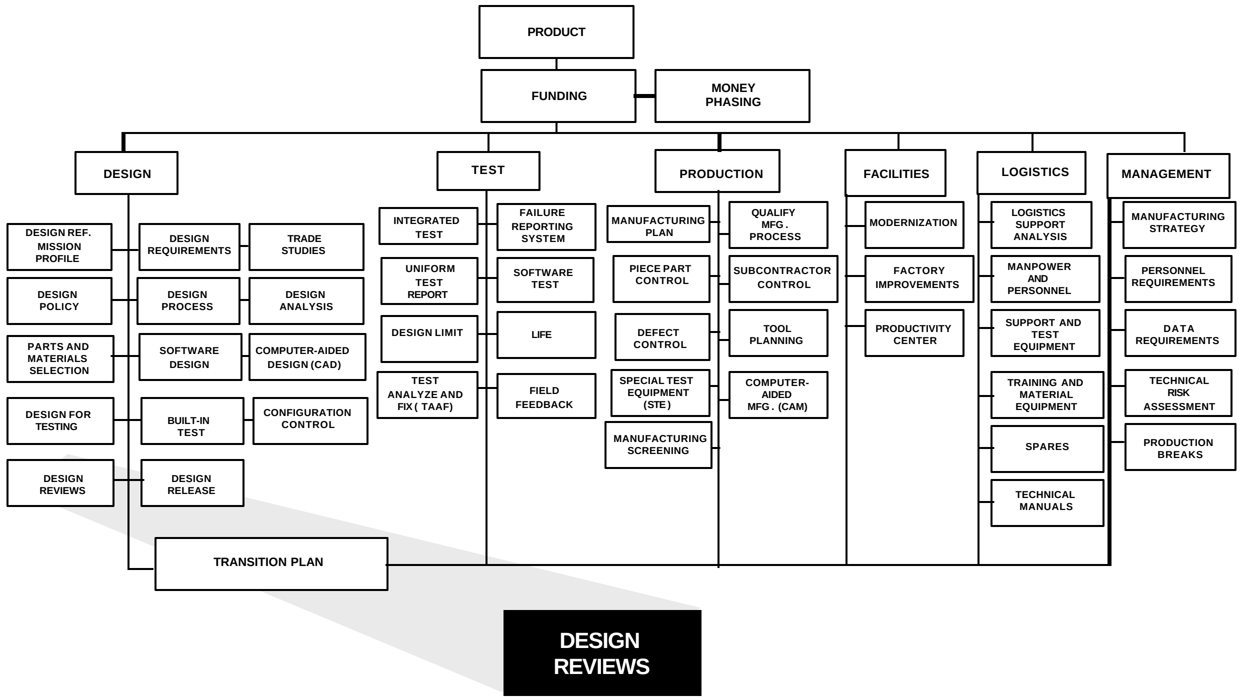
- Proper staffing and authority commensurate with responsibility are essential to the success of a configuration management organization.
- The specification tree, engineering release, and drawing discipline are managed by documentation requirements that have been established through the configuration management plan.
- Training in the established configuration management system is essential for a smooth configuration management program.
- A sound configuration management system recognizes that strict discipline is necessary to organize and implement, in a systematic fashion, the process of documenting and controlling configuration.
- Dynamic change control boards and status accounting systems that are updated frequently by timely feedback from user activities are indicative of effective configuration management.
- Good configuration control procedures ensure the establishment and maintenance of design integrity.
- Configuration audits are performed to establish the design baseline and to validate the drawing package before production release.
- Manufacturing engineering interfaces with configuration control of work instruction planning.
- The transition from contractor to Government responsibility is made when the design is largely mature and when field support will be enhanced.

## TIME LINE




The application of configuration control on a program is essential. For effective utilization, it should be tailored to fit the nature of the program. Configuration control policies are established early in the development and the design baseline configuration is stabilized before production.

TEMPLATE




## AREA OF RISK

While defense contracts usually require formal design reviews, they often lack specific direction and discipline in the design review requirement, resulting in an unstructured review process that fails to fulfill either of the two main purposes of design review, which are: (1) to bring to bear additional knowledge to the design process to augment the basic program design and analytical activity; and (2) to challenge the satisfactory accomplishment of specified design and analytical tasks needed for approval to proceed with the next step in the material acquisition process.

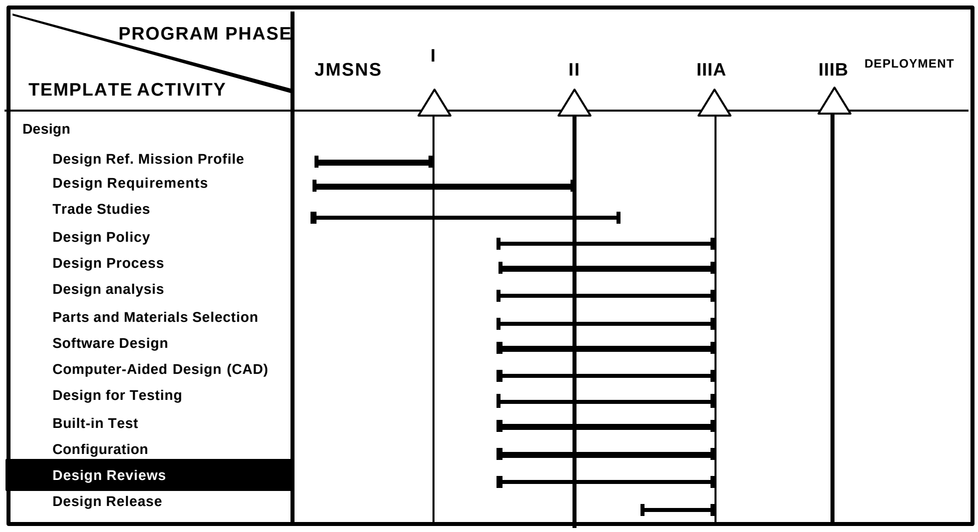
## OUTLINE FOR REDUCING RISK

- The Government and its contractors recognize that design reviews represent the “front line” where readiness for transition from development to production is decided ultimately. Design review policy, schedule, budget, agenda, participants, actions, and follow up are decided in view of this foremost need.
- Design reviews are included in all material acquisition programs in accordance with existing Government requirements. A design review plan is developed by the contractor and approved by the Government. The design review plan provides for both Government design reviews and internal contractor design reviews and inspections.
- Design review requirements flow down to subcontractors and suppliers to ensure proper subcontractor internal design review practices and to provide timely opportunities for both the contractor and the Government to challenge subcontracted material design.
- Government and contractor design review participants are selected or recruited from outside the program to be reviewed, on the basis of experience and expertise in challenging the design, and have a collective technical competence greater than or equal to that of the

designers responsible for the design under review.

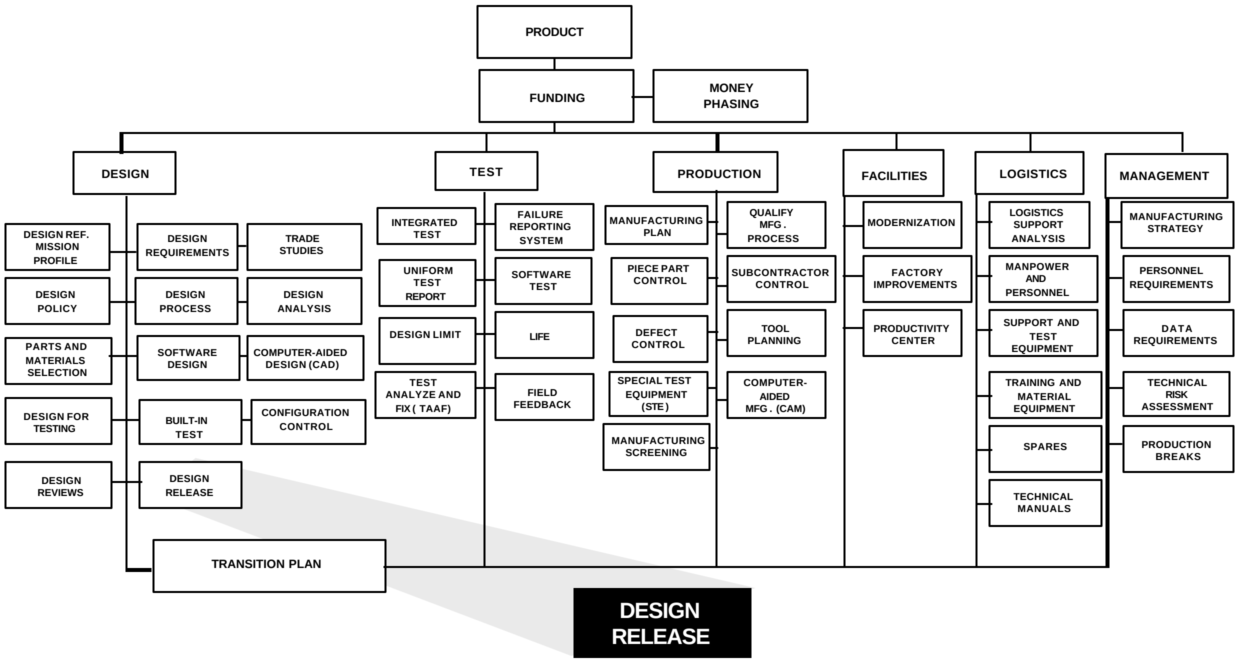
- Manufacturing, product assurance, and logistics engineering functions are represented and have authority equal to engineering in challenging design maturity.
- Design reviews use computer-aided design analyses, whenever available, and include review of production tooling required at the specific program milestone.

## TIMELINE




Design review must be performed by technically competent personnel in order to review design analysis results and design maturity, and to assess the technical risk of proceeding to the next phase of the development process. Design review policies are established before FSD, and the design reviews are completed by the conclusion of FSD.

TEMPLATE




## AREA OF RISK

One of the most critical concerns in the transition from development to production is the risk associated with the timing of design release. On many programs, design release schedules are established by "back planning" from manufacturing schedules or ambitious marketing considerations. As a result, the design engineer is expected to meet unrealistic milestones forcing him or her to deviate from standard design practices. The results are predictable: design solutions are not the most beneficial to the overall design, interface considerations are glossed over, costly redesigns occur, and necessary documentation is sketchy. Expedited and advanced design releases generally create the need for second and third generation effort. On the other extreme, when a design release is scheduled beyond the normal period required to complete the design, the designer is tempted to add undue complexity to the basic design rather than improve inherent reliability or maintainability or reduce costs.

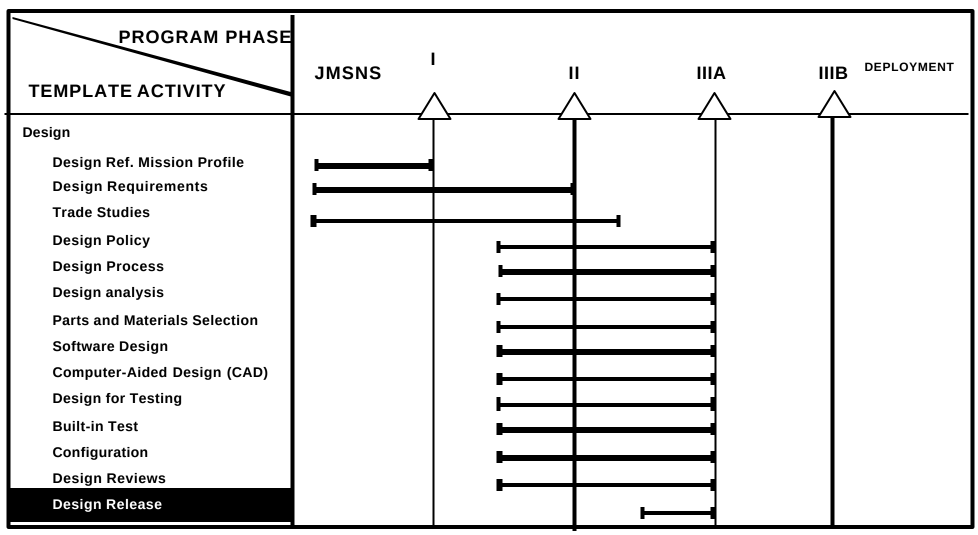
## OUTLINE FOR REDUCING RISK

- Documented corporate policy clearly identifies practices and procedures for design drawing releases to facilitate transition and reduce production risk.
- The design release disciplines practiced by the contractor are flowed down to subcontractors and suppliers.
- By applying uniform practices and procedures dealing with technical requirements and evaluating current manufacturing capability, realistic design release dates can be established.
- In areas of high manufacturing risk, alternate design approaches are planned and evaluated to ensure that the design release schedule is maintained.
- Complex designs are validated before design release by fabricating preproduction manufacturing models and feeding results back to design for corrective action. This step

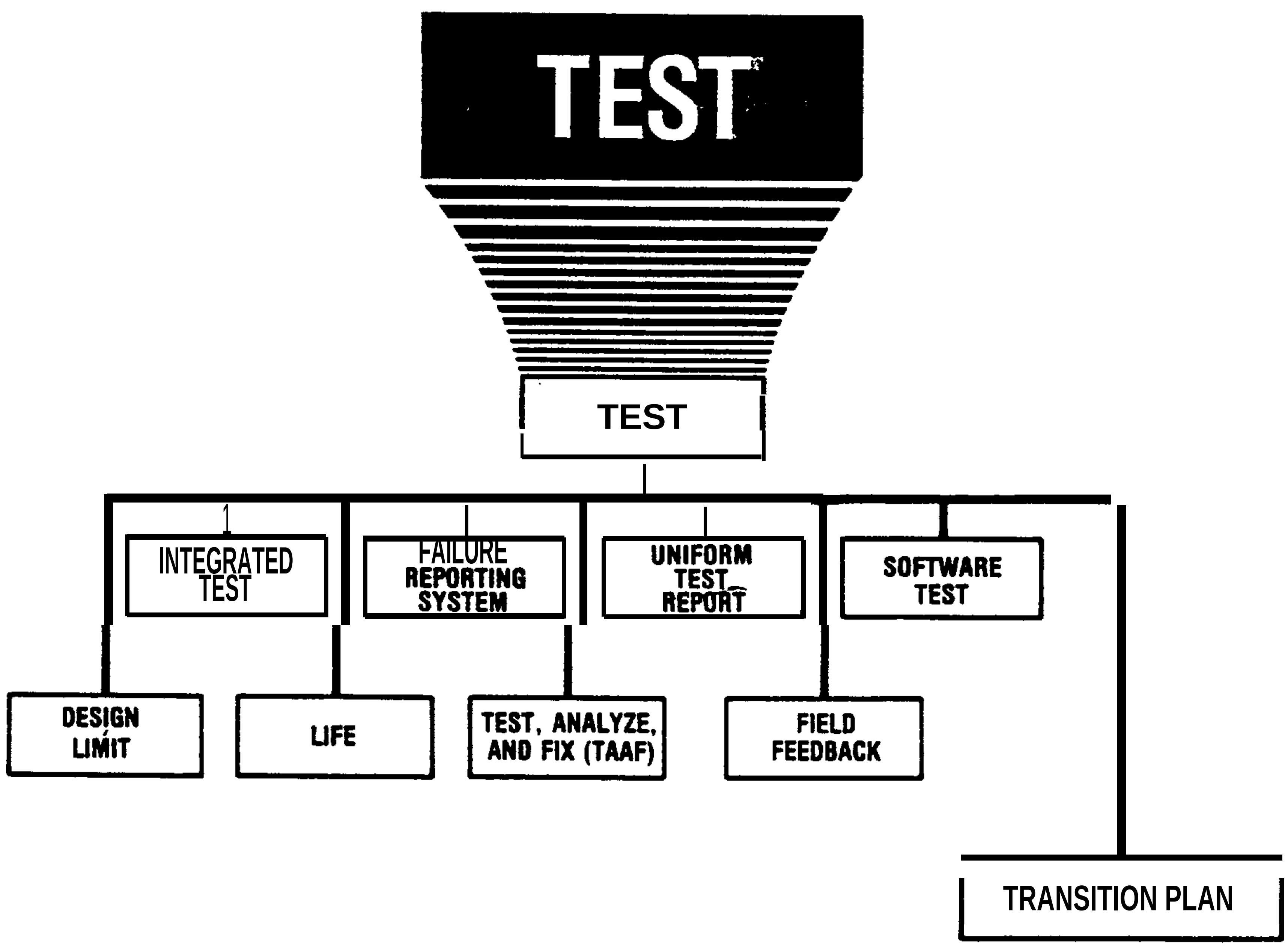
increases the assurance that the design release documentation will support full-scale production.

- The design release documentation includes all necessary information required for an orderly transition from design to production.
- A formal review of the design release documentation is conducted at the critical design review (CDR).
- The design baseline is established and validated as part of the design release.
- All design-related testing, including qualification testing, is completed before design release, to ensure that the design has reached acceptable maturity.

## TIMELINE




Integral to the development process are the facts that at some point, creative design must then be released to manufacturing.  Design release is completed with the acceptance of the design through the CDR and qualification test process.


TEST
TEST
INTEGRATED TEST
FAILURE REPORTING SYSTEM
UNIFORM TEST REPORT
SOFTWARE TEST
DESIGN LIMIT
LIFE
TEST, ANALYZE, AND FIX (TAAF)
FIELD FEEDBACK
TRANSITION PLAN

CHAPTER

# CHAPTER 4

## INTRODUCTION FOR TEST CRITICAL PATH TEMPLATES

During the development cycle of a weapon system various tests are performed by subcontractors, prime contractors, and the Government. In the early stages of development, these tests are used in evaluating design approaches and selecting design solutions for further development. As the design matures, the tests become more complex in attempting to provide confidence that the weapon system will perform satisfactorily in the actual operational environment.

As weapon systems have become more sophisticated, test requirements have been added with little consideration being given to possible duplication of effort or the elimination of older tests that no longer are needed. Attempts also have been made to "standardize" test environments. In many instances, these "standard" environments have shown little relation to the actual operational environment, resulting in costly engineering changes to weapon systems, after initiation of production and deployment, in order to correct basic design deficiencies that would have been detected" before production had a proper environment been used.

The DSB task force reviewed the test and "evaluation experience of several major DoD programs and the contributions of the test programs towards reducing the risk of transition from development to production. Areas investigated included topics such as integrated test plans; operational test environments; reliability development tests; reliability demonstration tests; software tests; Government participation in full-scale engineering development tests; initial operational test and evacuation; application of the test, analyze, and fix (TAAF) philosophy during transition; and the feedback of information from initial field use of production weapon systems.

The issues and guidelines provided in this section represent the most significant areas requiring special management attention in order to reduce the risk of transition from development to production. The process to integrate and document test requirements for the end item begins with the preparation and generation of the test and evacuation master plan (TEMP).

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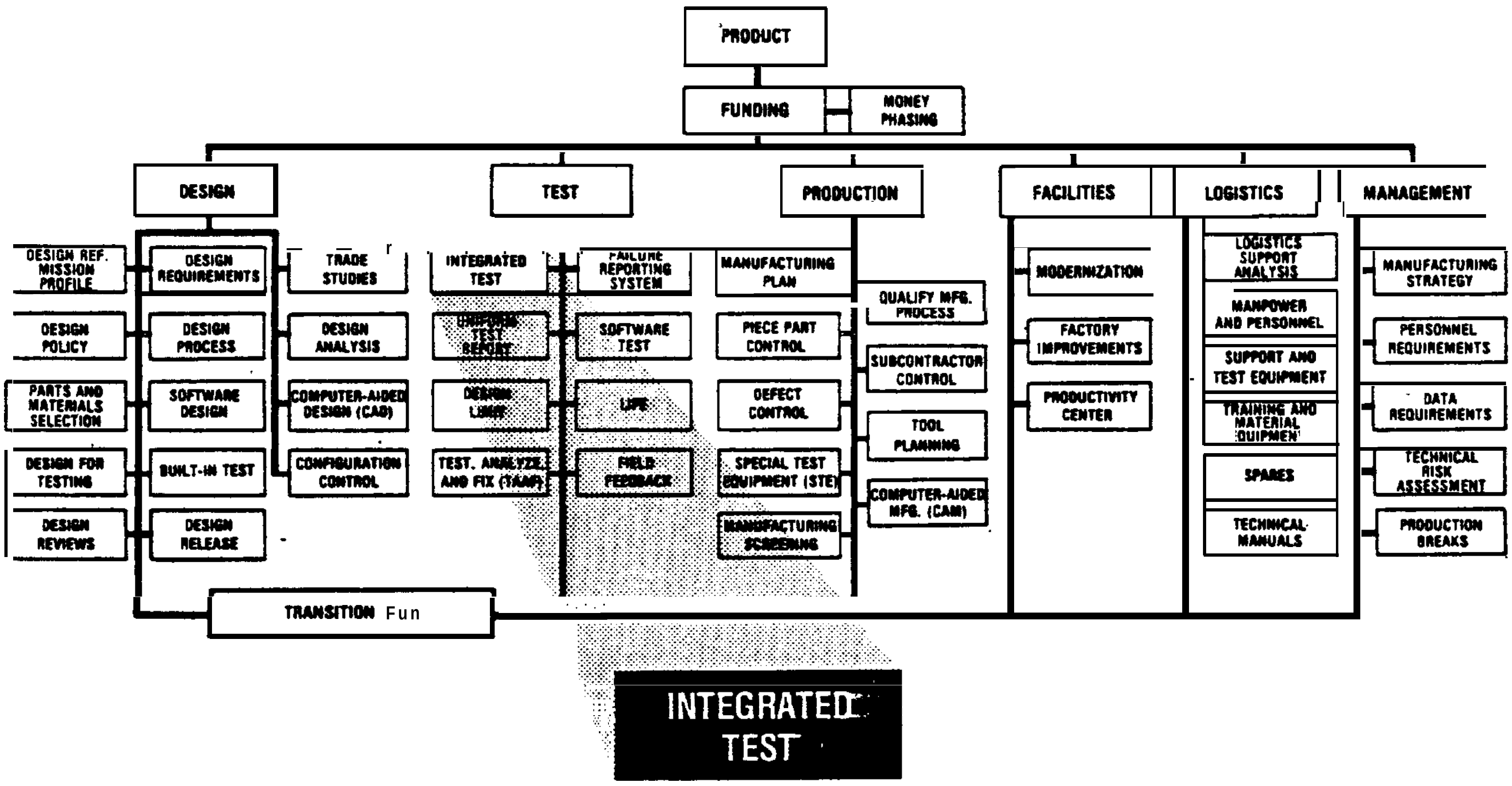



## AREA OF RISK

Although every development program has a defined test plan, this plan usually specifies a series of standard tests that have not been integrated properly. Integration includes the careful accounting of objectives, environments, test article configurations, data requirements, and schedules. Recognizing that T&E is a major cost driver, the objectives of test integration are to minimize overlaps and gaps, to collect maximum intelligence from every test, and to ensure a smooth and effective test program at minimum cost. The absence of a carefully integrated test plan is a certain indicator of a high risk program.

Critical parameters and characteristics measured in production acceptance tests (PATs) do not give a sufficiently high level of confidence that the product meets its specification. Production configuration changes introduced without recertifying the validity of the PAT further increase product risk.

## OUTLINE FOR REDUCING RISK

- Early in the program initiation phase an integrated test plan (ITP) is prepared by the prime contractor for Government approval that maximizes efficiency in testing, as follows:

  - Includes *all* development and qualification tests (prime contractor, subcontractors, and Government) at the system and subsystem levels.

  - Identifies duplicate test activities and missing test activities.

– Provides for the most efficient use of test facilities and test resources.

- This ITP is updated periodically.

- Government participation in contractor testing of weapon systems includes operating the system a portion of the time during FSD. .

- Initial operational test and evaluation (IOT&E) is conducted during the transition from development to production, using the latest available configuration, when possible. ,

- Qualification test articles are representative of production units.

- Production acceptance testing is conducted on all production items, to ensure the continuing effectiveness of the manufacturing processes, equipment, and procedures. This includes revalidation of acceptance test procedures. when significant changes occur in the configuration or the production processes.

- Ensure that test tolerances are funneled from component (most restrictive) to system (least restrictive) within system specification performance parameters.

- Reasonable probability that the product meets previously qualified performance requirements is demonstrated by the production acceptance test, in terms of both thoroughness and severity, as a prerequisite to product acceptance by the Government.

- Figure 4-1. shows the essential elements of an ITP.

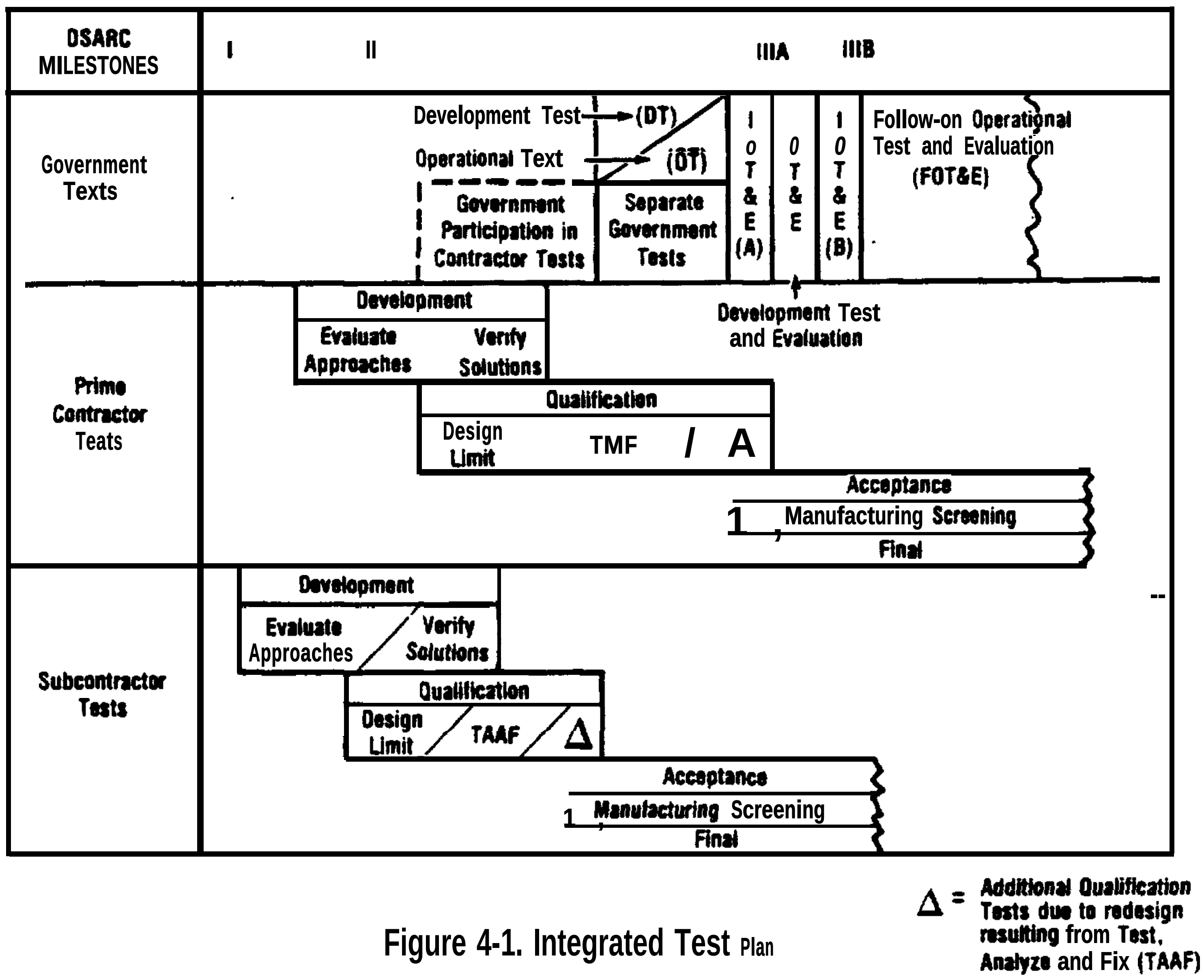
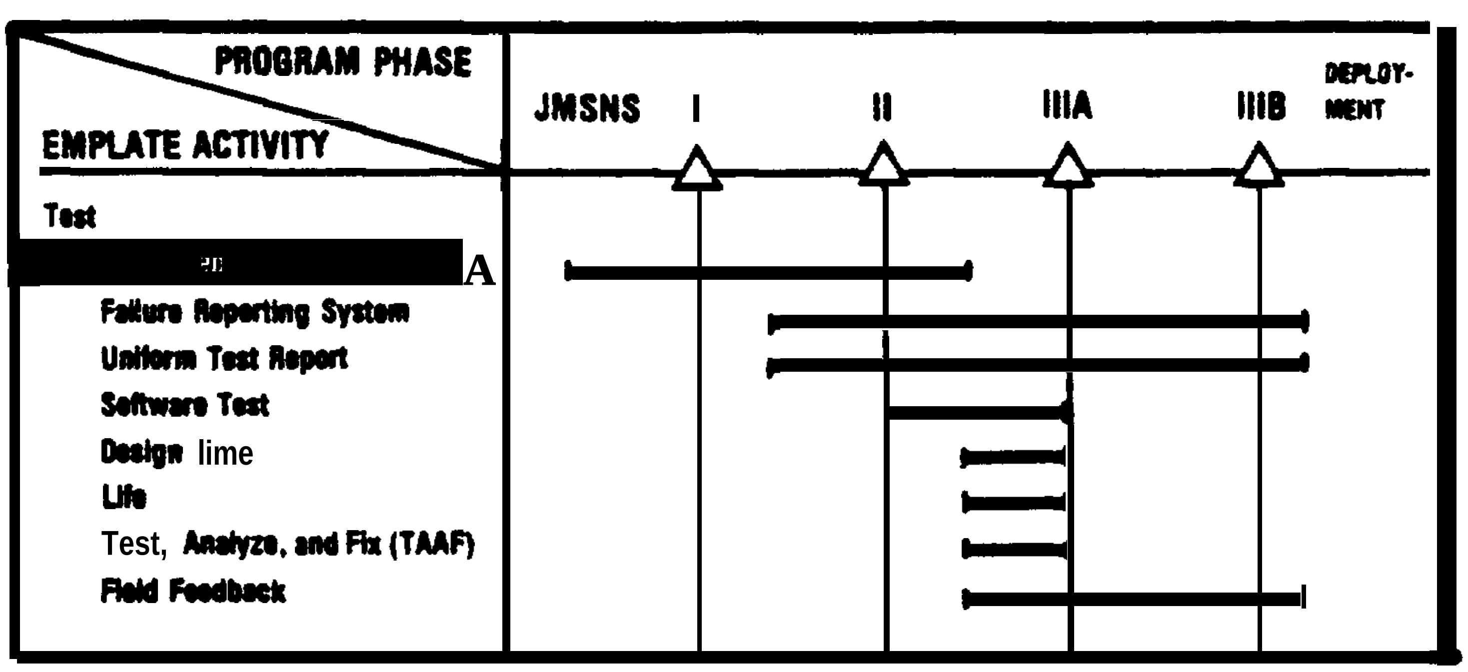



Figure 4-1. Integrated Test Plan

## TIMELINE




To ensure that all development tests are properly time phased, that adequate resources (for example, test articles, test facilities, funding, and manpower) are available, and that duplicative or redundant testing is eliminated, a properly integrated test program is required. This activity must start early in concept development and continue into FSD.

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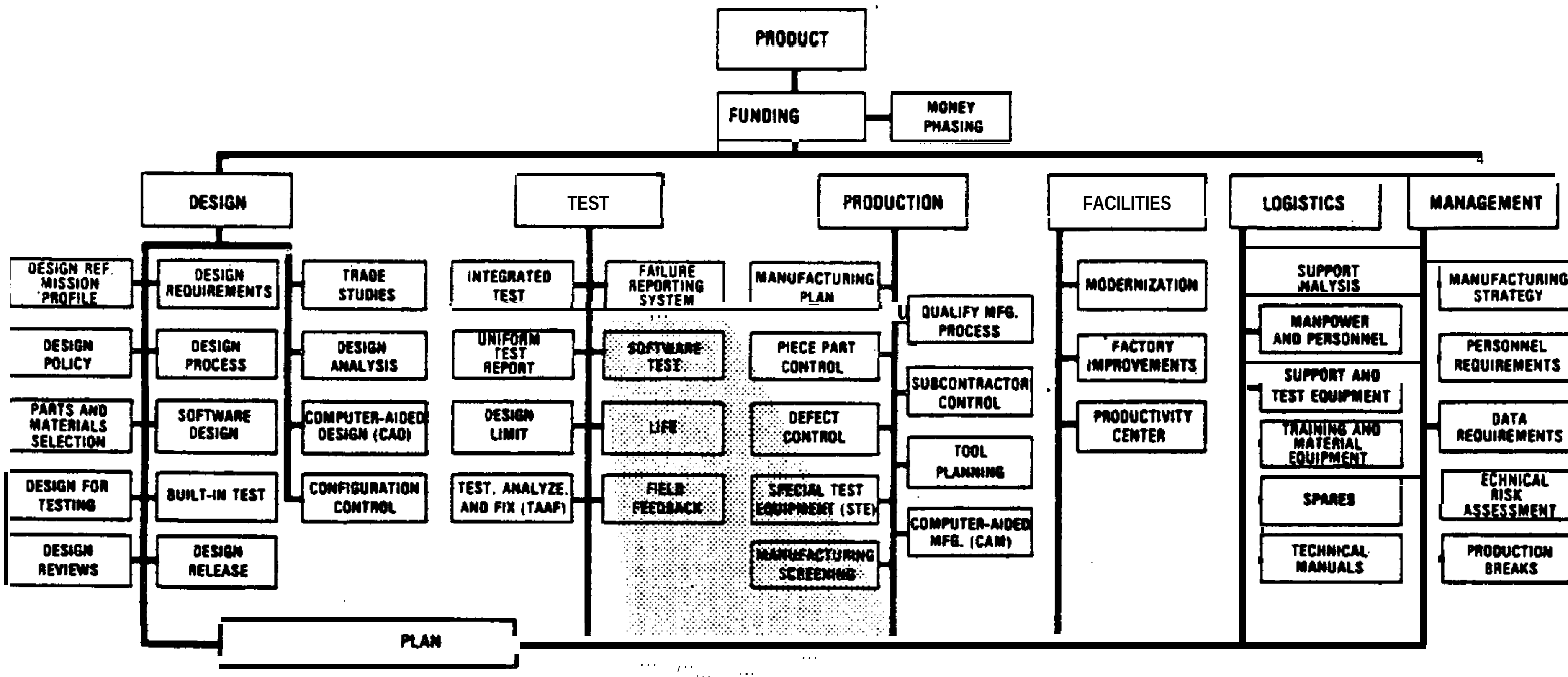
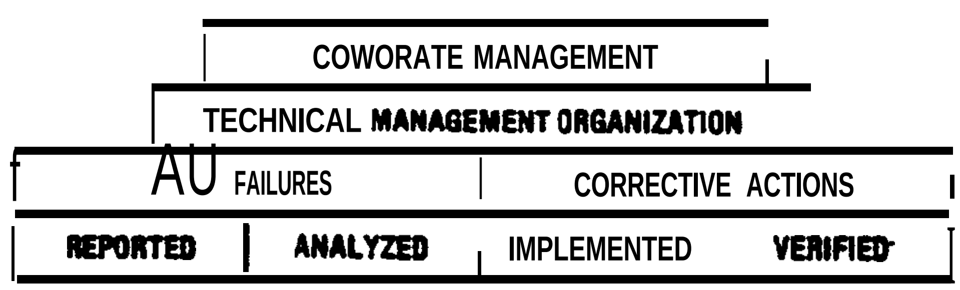



**FAILURE REPORTING SYSTEM**

## AREA OF RISK

The ultimate objective of a failure "reporting, analysis, and corrective action system (FRACAS) is to devise corrective actions, which prevent failure recurrence, for incorporation into the system or equipment. Although there are several military standards, such as Military Standard (MIL-STD) 785B (reference (e)) and MIL-STD 781 C (reference (f)), that require FRACASs, the implementation of these requirements has been managed poorly, defined improperly, and undisciplined. The flow down of requirements from prime contractor to subcontractors has not been uniform, analysis of all failures has not been required, the timely closeout of failure reports has been overlooked, and systems for alerting higher management to problem areas have been missing.

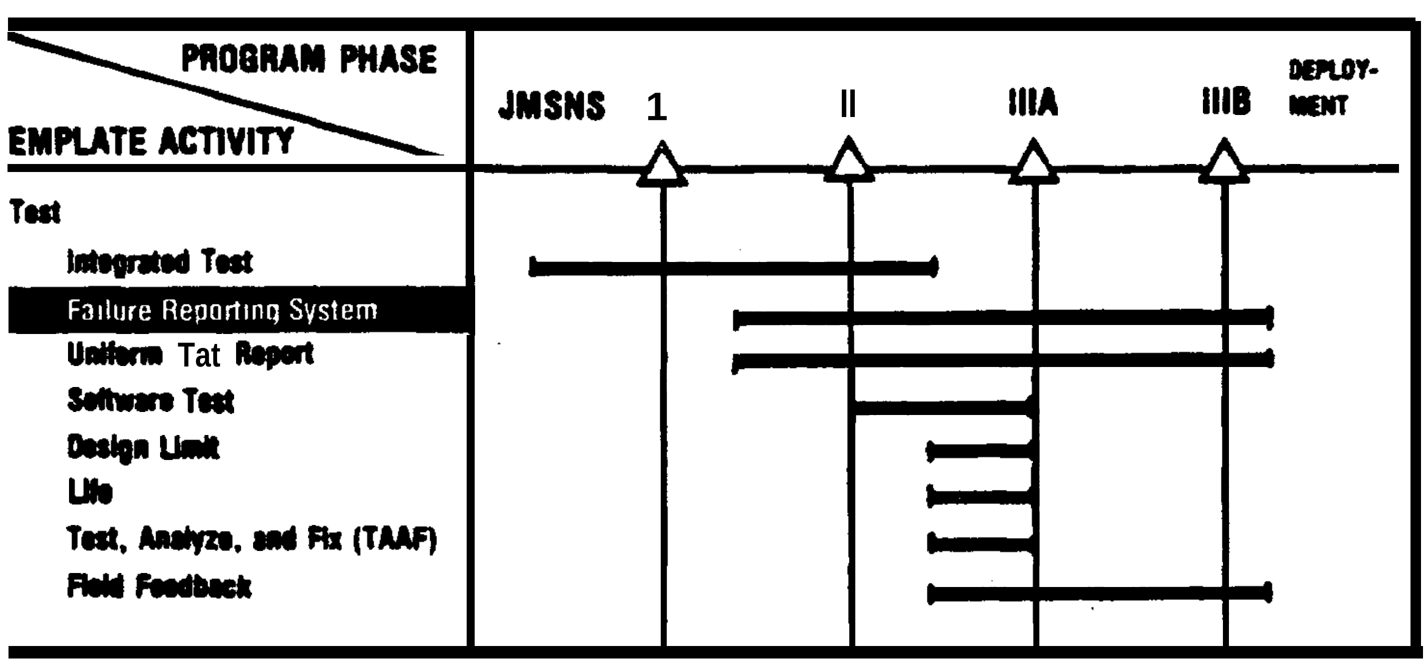



## OUTLINE FOR REDUCING RISK

- A central technical organization is responsible for implementation and monitoring.
- A FRACAS is initiated at the piece part level.

- Uniform requirements are imposed on subcontractors, prime contractors, and Government activities.
- All failures are reported.
- All failures are analyzed to sufficient depth to identify failure cause and necessary' corrective actions.
- All failure analysis reports are closed out within 30 days of failure occurrence, or rationale is provided for any extensions.
- Corporate management automatically is alerted to failures exceeding closeout criteria.
- Corporate management automatically is alerted to ineffective corrective actions.
- Small subcontractors lacking facilities for indepth failure analysis arrange for the use of prime contractor, Government, or independent laboratory facilities to conduct such analyses.
- Criticality of failures is prioritized in accordance with their individual impact on operational performance.

## TIMELINE




A FRACAS will be effective only if the reported failure data is accurate. The failure reporting system is initiated with the start of the test program and continues through the early stages of development.

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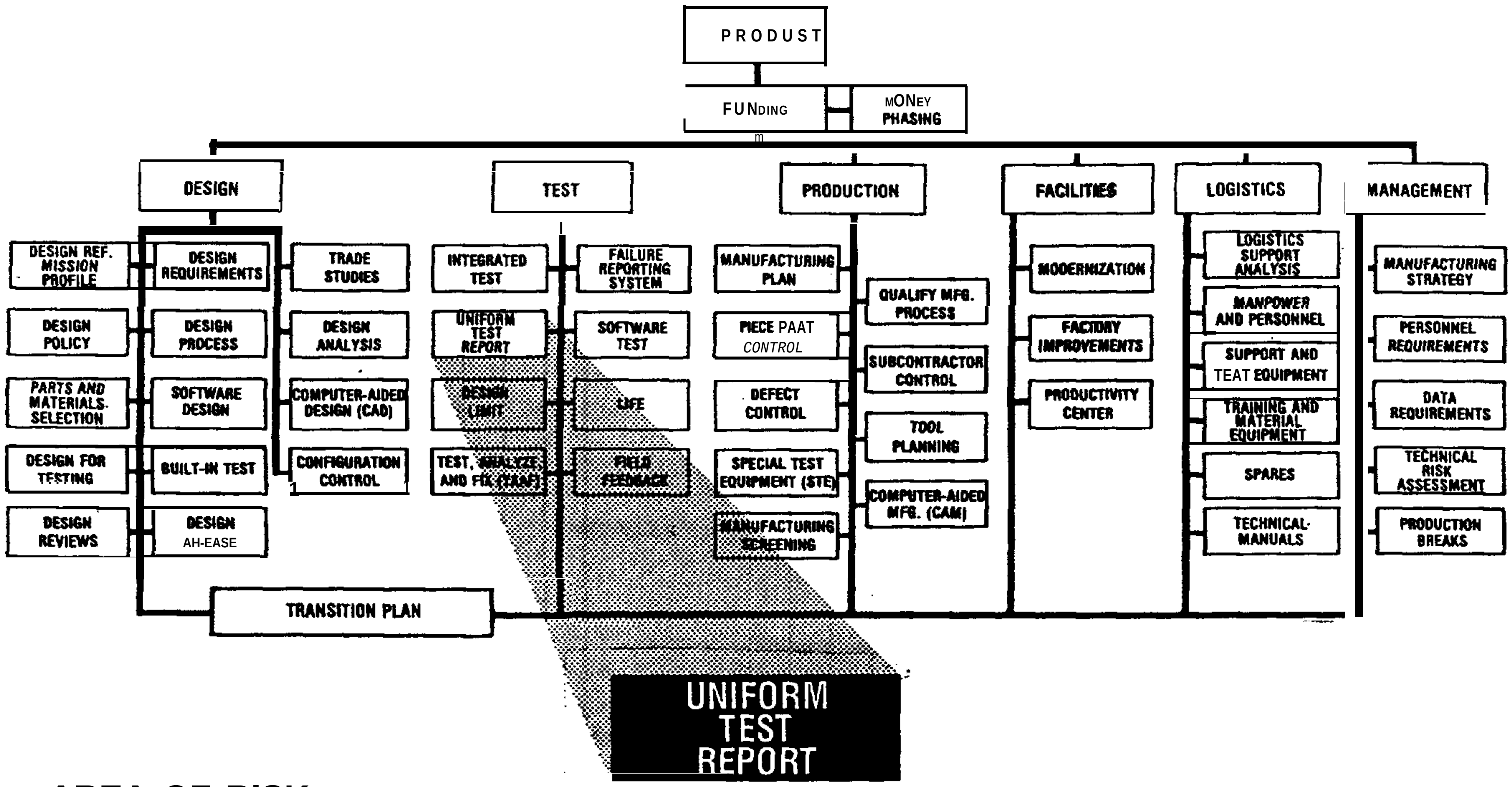



## AREA OF RISK

Formal reliability development tests using the TAAF methodology normally are performed for failure mode identification and elimination. During these tests, all results are reported in a format that provides acquisition managers with visibility of actual versus predicted reliability growth. Results from other tests being performed during the development and transition phases usually are reported in different formats. This change in format precludes merger of test results and prevents an overall assessment of design maturity by acquisition managers.

## OUTLINE FOR REDUCING RISK

- *All* test results, including initial field operations, are reported using the TAAF format, an example of which is shown in figure 4-2.
- Plotted results are used to assess design maturity and readiness for transition from development to production.

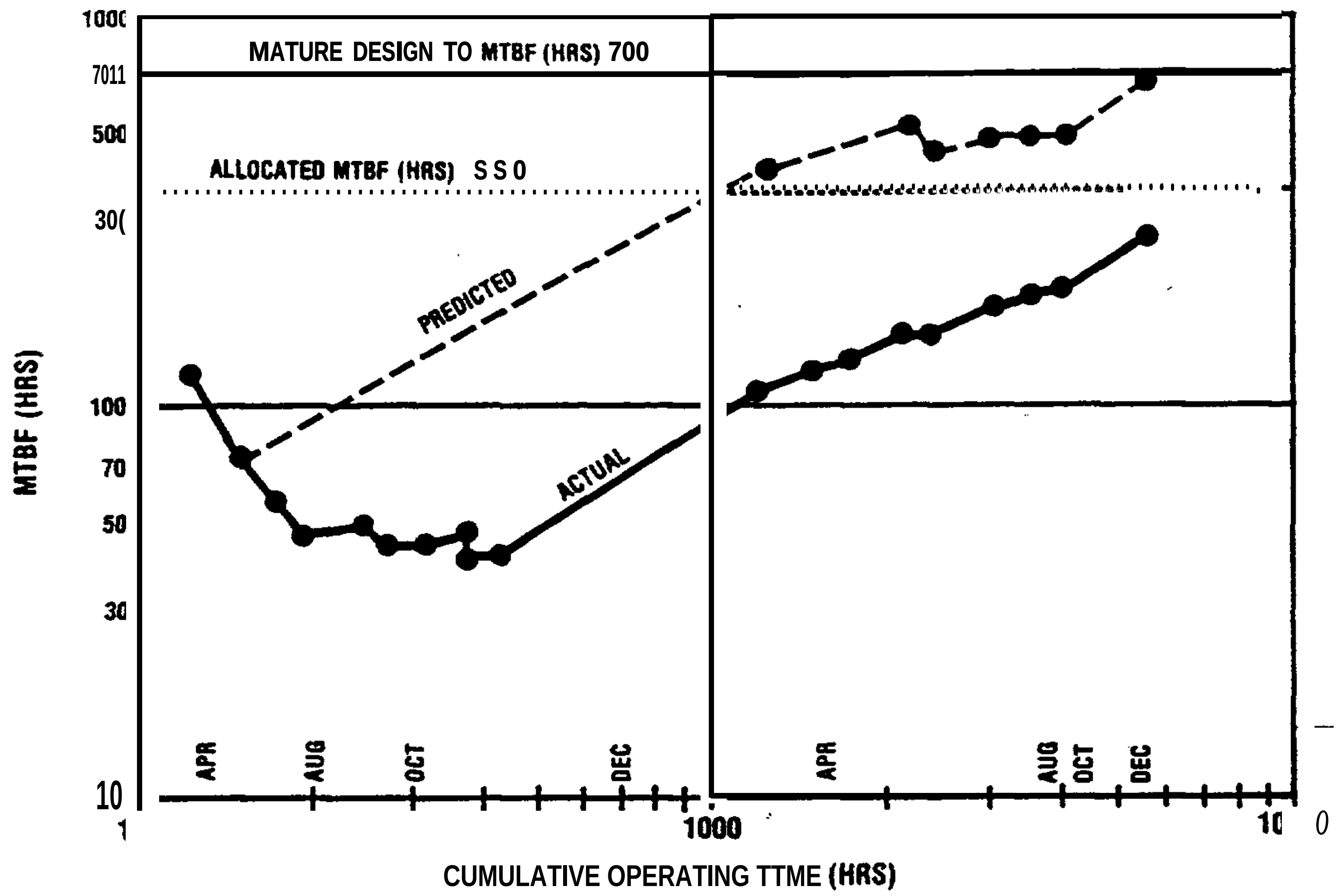
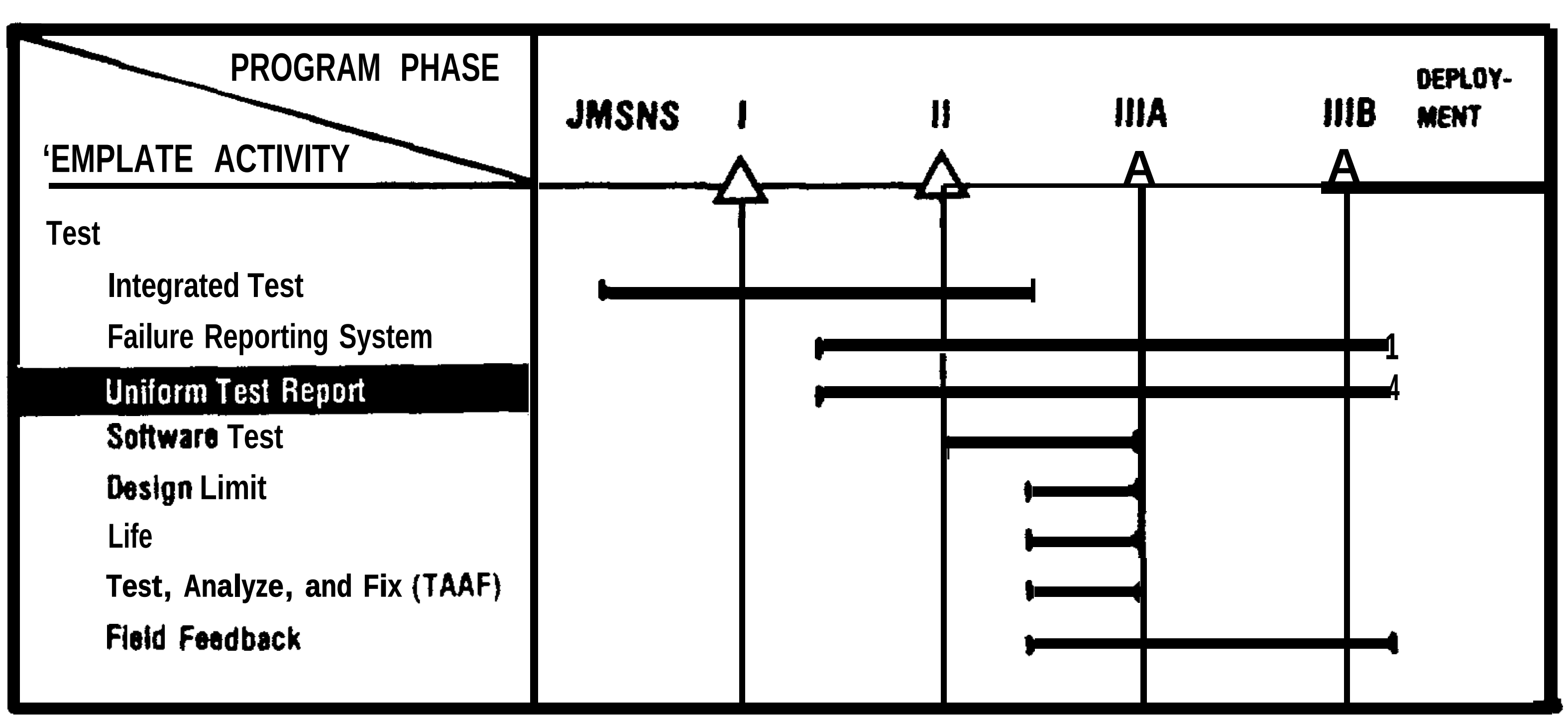



Figure 4-2. Growth Tracking Chart

## TIMELINE




**All test data must be collected in the” specified TAAF format and analyzed to determine reliability growth. Reporting test results in the TAAF format begins with the earliest program testing and continues into service *use* to allow a uniform baseline to evaluate failures and corrective actions.**

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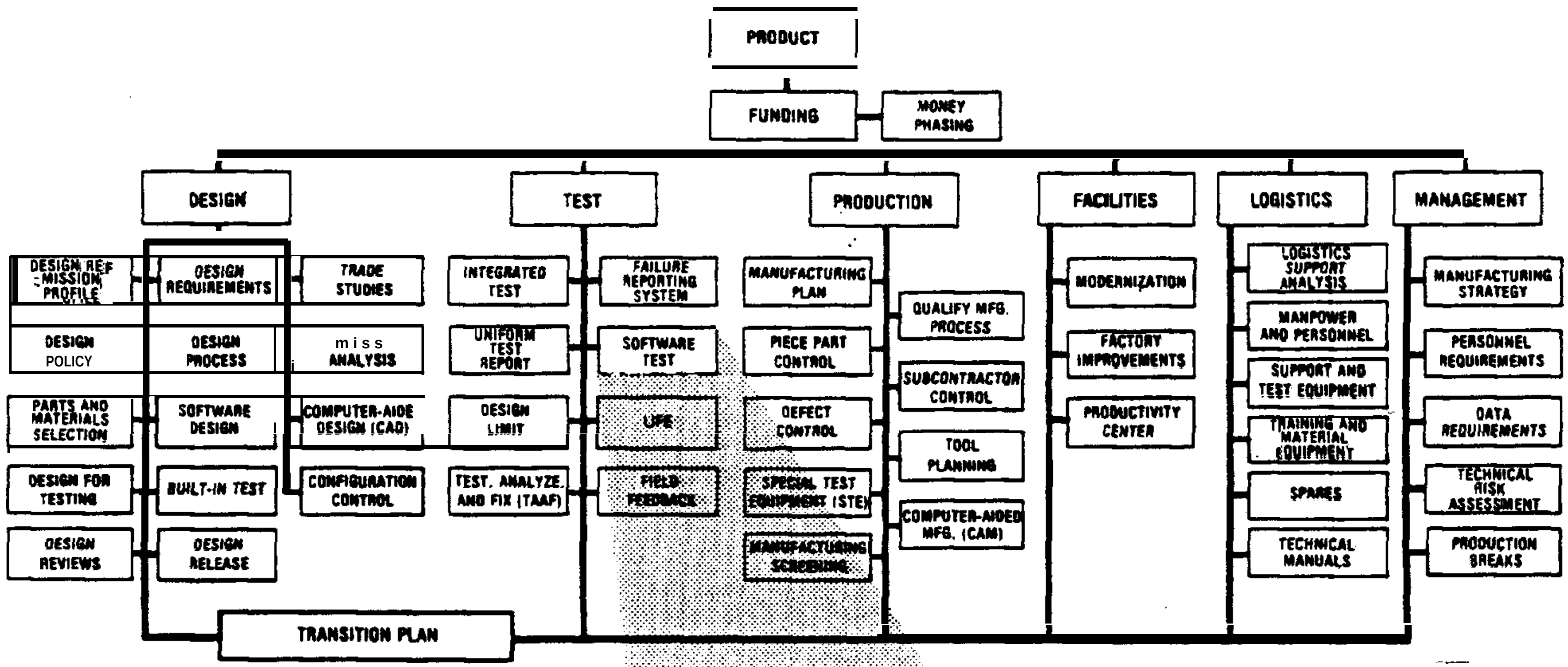



**SOFTWARE TEST**

## AREA OF RISK

There is no way to test all possible paths during a development and acceptance test for a complex system involving immense logic complexity. Some of these. paths eventually will be exercised after the system is deployed and some legitimate user interfaces will occur that were not tested specifically. These will result in software errors.

Many past studies on hardware illustrate how the cost of correcting a design error multiplies if the problem is not found until acceptance testing, production, or deployment. The same applies to software, but the cost for correcting software design errors after the design phase multiplies at a much greater rate.

Figure 4-3. is based on combined data from four major contractors and shows a multiple of 100:1 for cost to correct a design error after the system is operational.

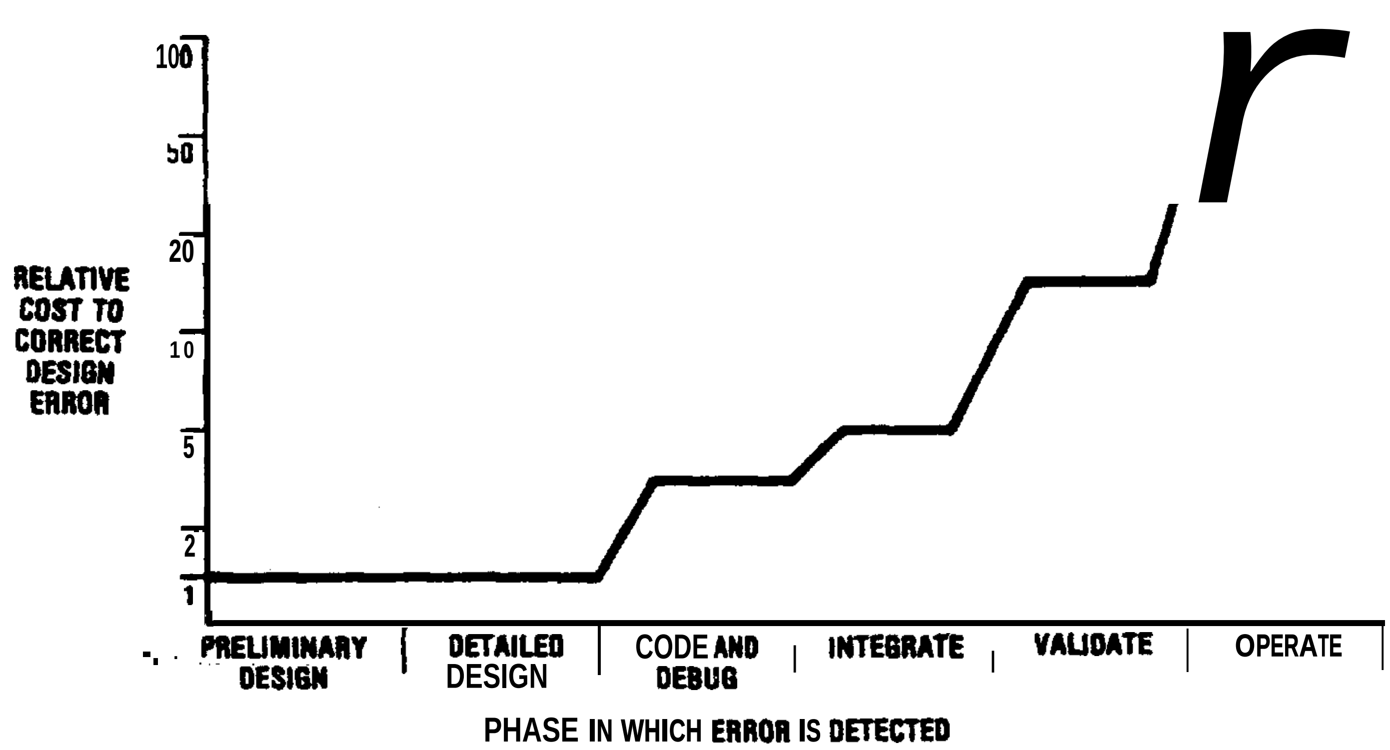
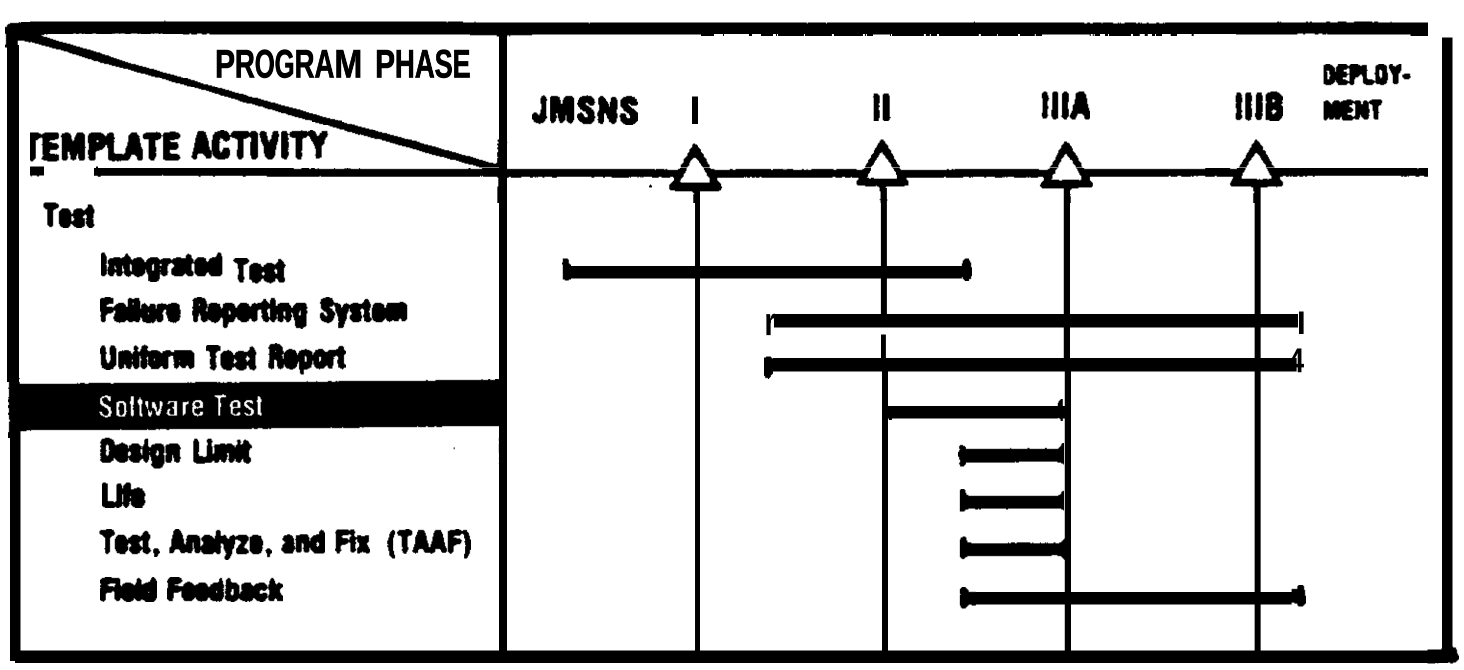



Figure 4-3. Relative Cost to Correct Design Error

## 'OUTLINE FOR REDUCING RISK

- Up front money is available for testing software early in the design phase to prevent design and coding errors from being discovered after deployment.
- The software design allows the product to be testable. The test group is an active participant in software design reviews to ensure that the design is testable to the greatest degree.
- An independent test group is used to initiate the software test plan and to initiate testing at the functional module level earty in the program.
- Test readiness reviews are used to ensure good software test planning.
- For extremely high reliability requirements, the verification and validation approach is used. An independent test group is used to verify by analysis or test every important test action.
- Useful definitions of error and failure are developed and software reliability growth is tracked during all test phases using a closed loop failure reporting system. Every failure is analyzed placing special emphasis on resolving anomalies.
- Stress testing and "worst case" testing are utilized to ensure that adequate design margins exist in memory loading, data rates, port timing, and other critical parameters.
- Security requirements are considered during software testing.

## TIMELINE




The best approach in testing software is through testing at each of the early stages of design and coding to reduce the probability of errors escaping and surfacing during system integration tests and field use. Assurance of software/hardware interface compatibility is obtained by exhaustively testing the software in a total system, test bed.

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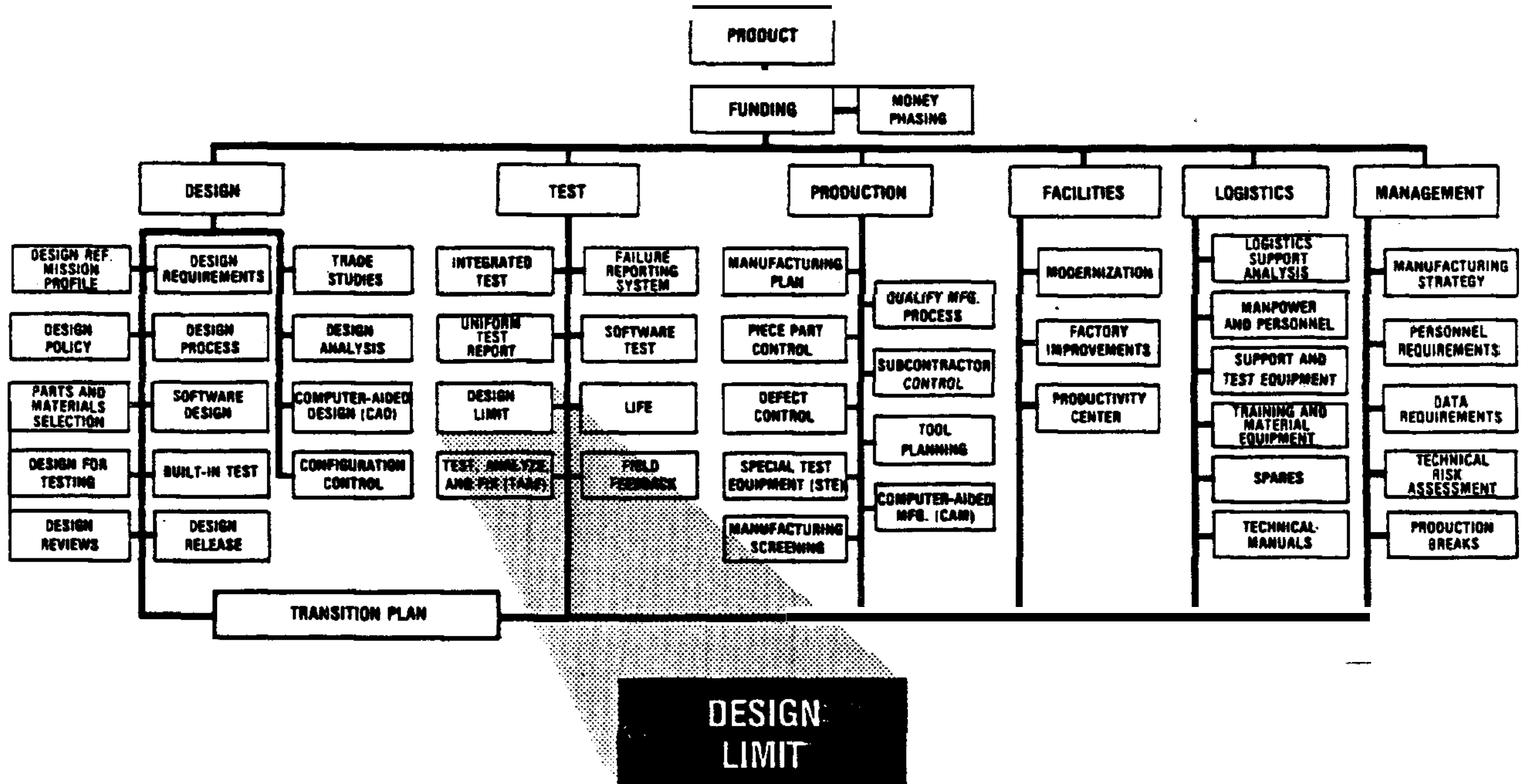



## AREA OF RISK

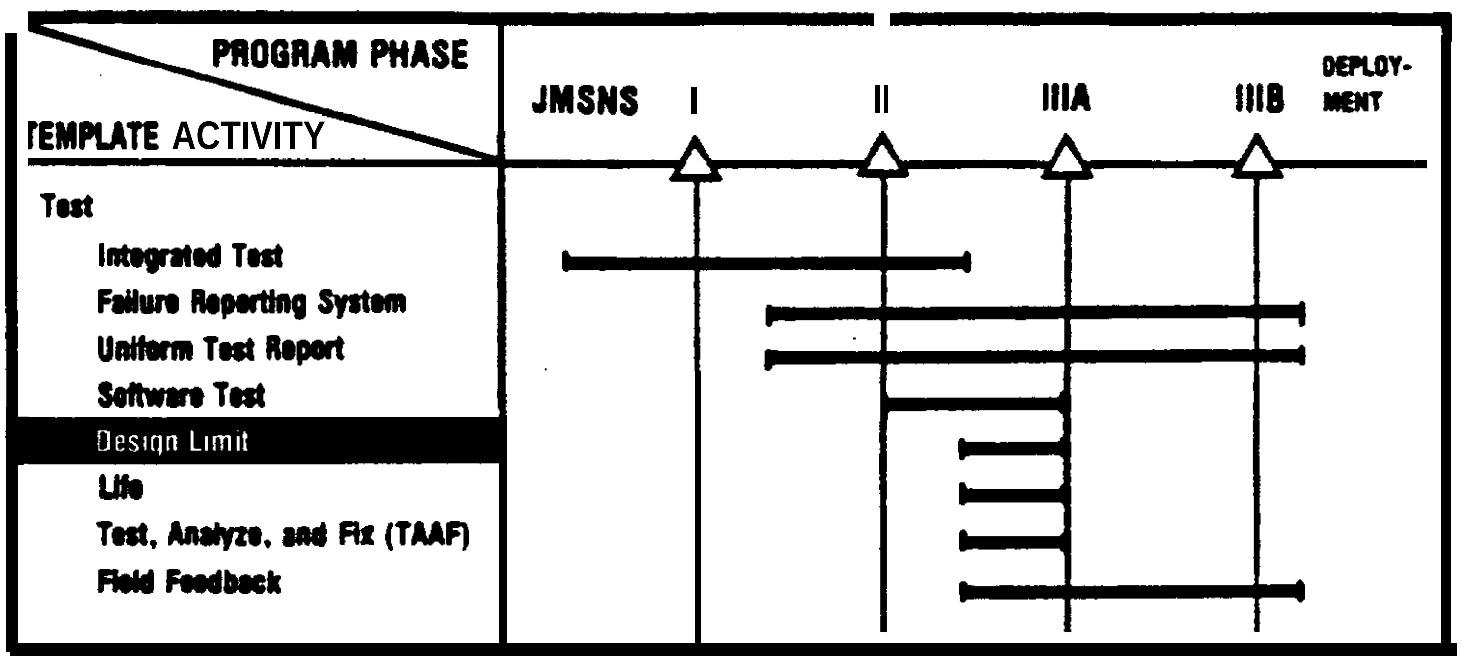
Design limit tests are intended to ensure that system or subsystem designs are adequate to meet specified performance characteristics when exposed to “worst case” environmental conditions expected at the extremes of the operating envelope. Nevertheless, test environments often are not representative of the “worst case” operating environment, resulting in high risk of poor performance during operational use.

## OUTLINE FOR REDUCING RISK

- One specific set of system-level test environments based on expected operational (mission profile) environments is used.
- System-level operational test environments are allocated to each subsystem and tailored to the expected operational environment for each subsystem.
- Design limit qualification test environments are based on the “worst case” conditions in the system and subsystem life cycle profiles.
- Contractors are provided with measured environmental data to use in developing test environments.
- Test environments are modified ss additional environmental data become available.
- Failures occurring during design limit qualification testing are investigated thoroughly to determine the mechanisms of failure, so that corrective action can be initiated. Timeliness is important to ensure cost-effective design improvements.

- Design limit qualification testing is conducted on critical hardware at the lowest level of assembly.
- A test history file is maintained on design limit qualification tests for future use on the program and as a reference for new programs.
- Subsystem qualification tests are scheduled and conducted so that completion occurs before the production decision.

## TIMELINE




Design limit tests ensure that system or subsystem designs meet performance requirements when exposed to environmental conditions expected at the extremes of the operating envelop-the "worst case" environments of the mission profile.

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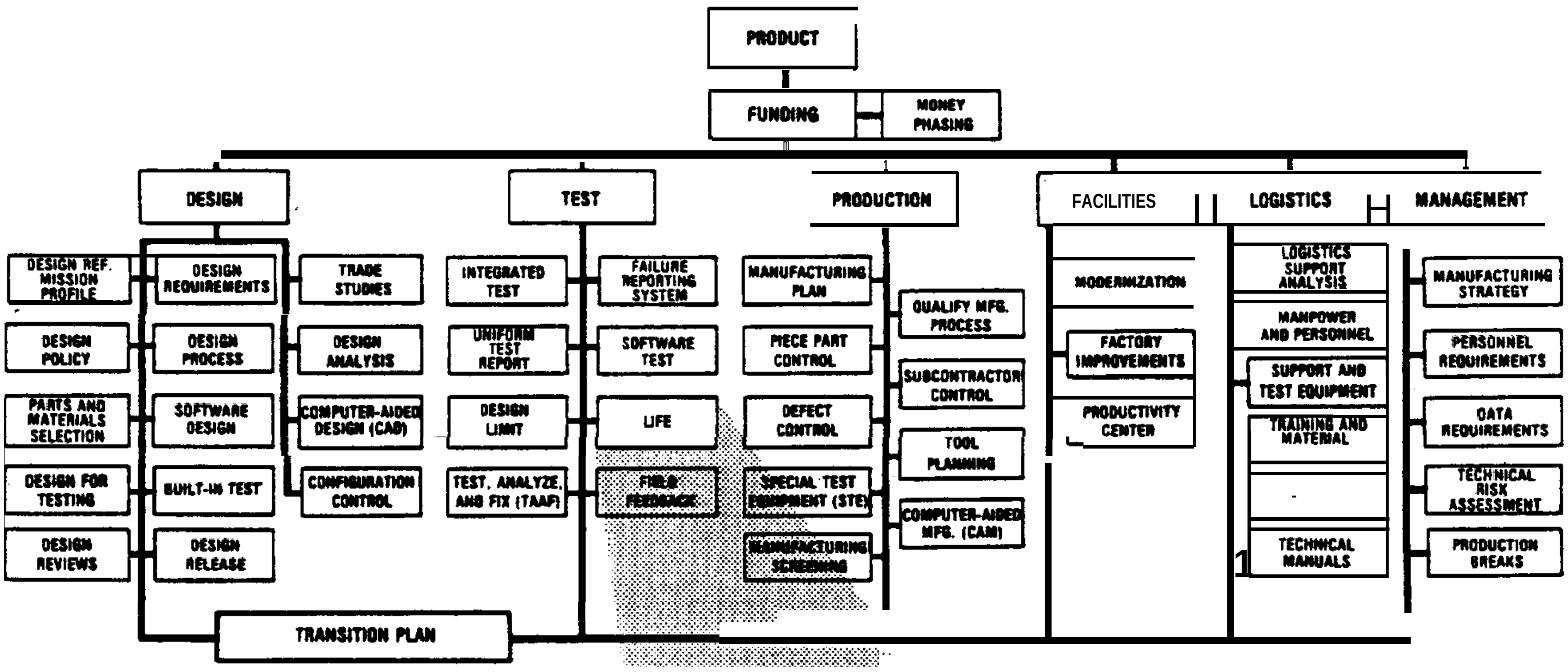



**LIFE**

## AREA OF RISK

Life tests are intended to assess the adequacy of a particular equipment design when subjected to long-term exposure to certain mission profile environments. Due to the time-consuming nature of these tests, various methods have been used to accelerate test times by exposure to more stringent environments than those expected in actual operational use. These methods may give misleading results due to a lack of understanding of the acceleration factors involved, for example, recent attempts to develop accelerated life tests to verify long-term dormant storage requirements for missiles.

Many weapon system programs are forced into conducting life tests after the systems are deployed and before reliability requirements are achieved. As a result, life tests are performed after the start of production and costly engineering change proposals (ECPs), and retrofit programs must be initiated in an attempt to “get well” with less than optimum design solutions.

## OUTLINE FOR REDUCING RISK

- Include life testing in the overall system integrated test plan to ensure that testing is conducted in a cost-effective manner and to meet program schedules.
- Use test data from other phases of the test program to augment the system and subsystem life testing by reducing the time required to prove that reliability requirements are met.
- Use life-test data from similar equipments operating in the same environment to augment the equipment life testing, in order to gain confidence in the design. For example, this technique is useful particularly when determining the long-term dormant life expectancy of a missile.

- **Conduct early assessment of operational life expectancy through realistic life testing that will ensure timely feedback of test results to design activities.**

- **Develop realistic life test environments based on operational mission profile environments. Experience gained from previous programs is useful in developing life test parameters.**

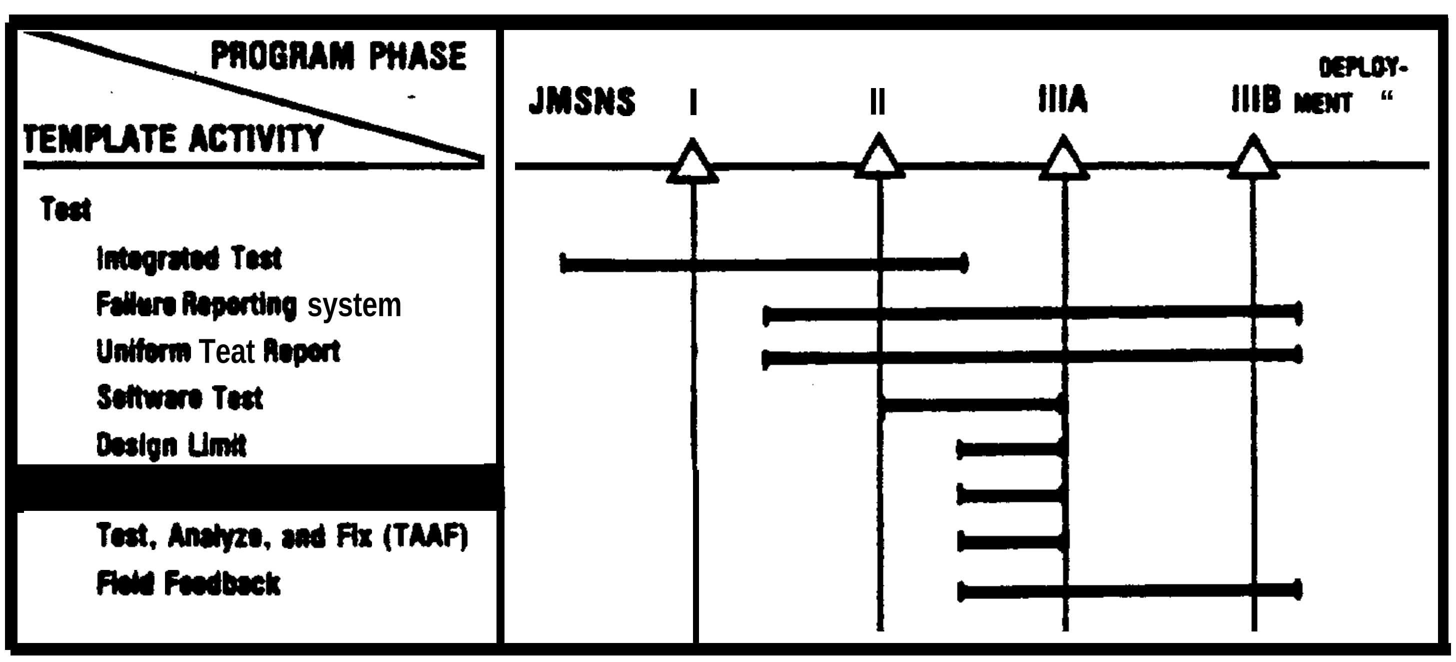
- **Use oniy proven, weii understood, accelerated testing techniques in the design of iife tests.**

- **Analyze failure data originating from iife tests in sufficient depth to identify the root cause of failure, so that the proper design correction can be implemented.**

- **A well-designed iife testis an excellent measure of the level of design maturity.**

- **Fatigue life tests should be conducted to loading spectra that will determine the inherent strength of the parts so that their lives can be recalculated should the operational mission profile be changed or revised test conditions differ from those calculated.**

## TIMELINE




**A well-designed iife testis an excellent measure of the level of design maturity and is used to establish life characteristics. Life testing is integrated with other development test activities and is completed before design release.**

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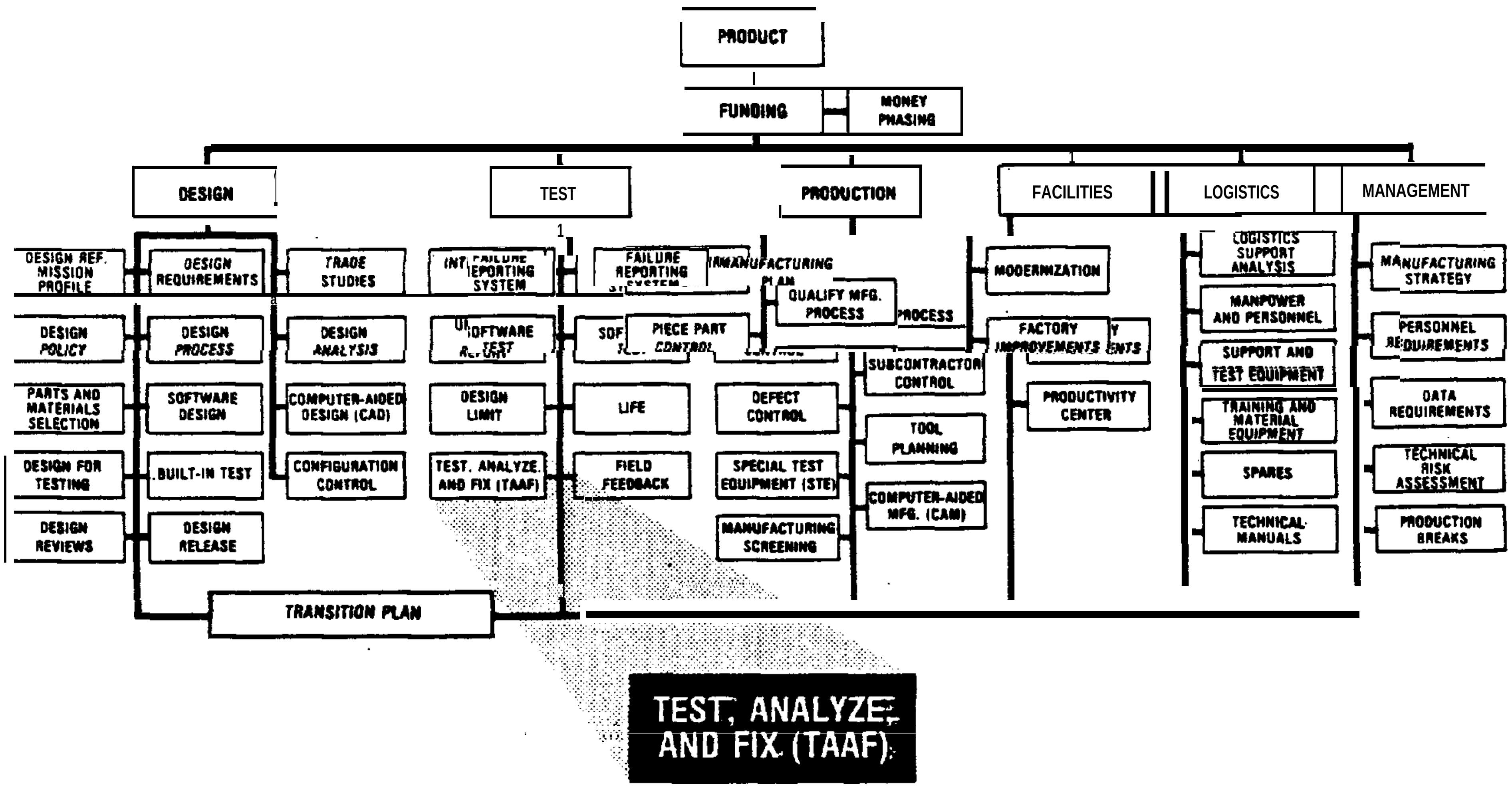



## AREA OF RISK

Many past development contracts have not given proper emphasis to reliability development testing, utilizing the TAAF methodology. Instead, they limit their approach to a reliability test to demonstrate a numerical mean time between failure (MTBF) requirement. This latter approach has been ineffective in providing weapon systems with acceptable field reliability. Reliability development testing (TAAF) using simulated mission environments and emphasizing reliability growth has proven a more effective use of limited test resources' and has reduced the risk of allowing systems with poor reliability to transition from development to production. TAAF is consistent with the growth requirement of DoD Directive 5000.40 (reference (g)).

## OUTLINE FOR REDUCING RISK

- Reliability development tests are performed instead of reliability demonstration tests, which are nonproductive cost and schedule drivers.

- Reliability development test resources are directed to subsystems of low (predicted) reliability when improvement will have a significant influence on overall weapon system reliability.

- If subsystems of high (predicted) reliability exhibit reliability problems during other development tests, such subsystems are incorporated in the reliability development "test program.

- For 'most efficient use of test resources, reliability development tests are integrated with other tests, such as environmental qualification tests, to avoid duplication.

- Reliability development tests use mission profile environments.
- The predicted MTBF is at least 1.25 times the required MTBF (see figure 4-4.).
- An initial MTBF estimate of 30 percent of the predicted MTBF should be used for low risk programs. A substantially lower estimate, as low as 10 percent in some cases, should be used for high risk programs.
- A growth slope of 0.5 can be achieved by a well-executed program.
- There are no random failures-ail failures require analysis and implementation of corrective action to prevent their recurrence.
- Results of reliability development tests and other development and operational tests are used to assess reliability.
- Reliability development tests are terminated when further tests produce insignificant improvements.
- A typical reliability development test example is shown in figure 4-4. for both low risk and high risk programs.

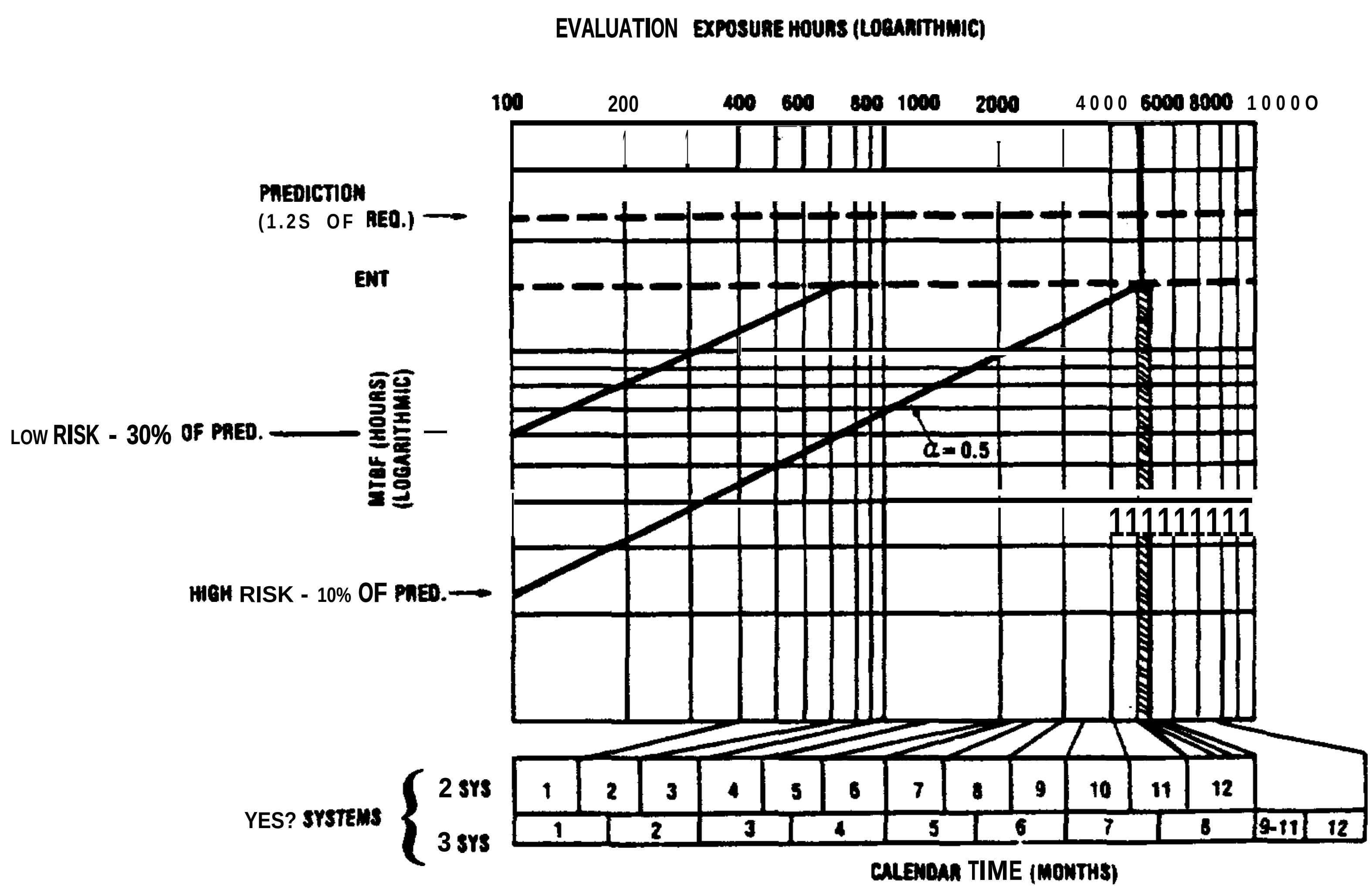
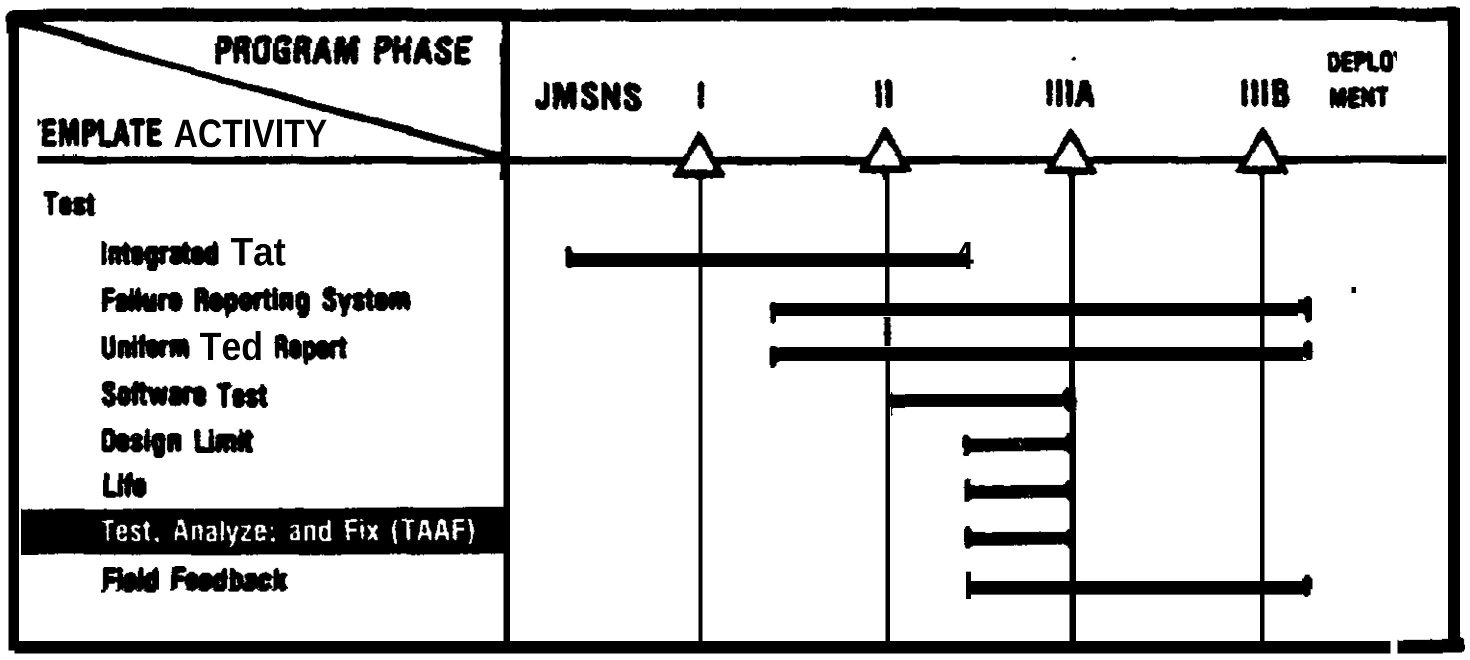



Figure 4-4. Reliability Development Test Planning Model

## TIMELINE




TAAF tests are implemented during FSD, to ensure the early incorporation of corrective action necessary for continuous reliability growth. TAAF tests are integrated with other test activities and are completed before the initial production decision.

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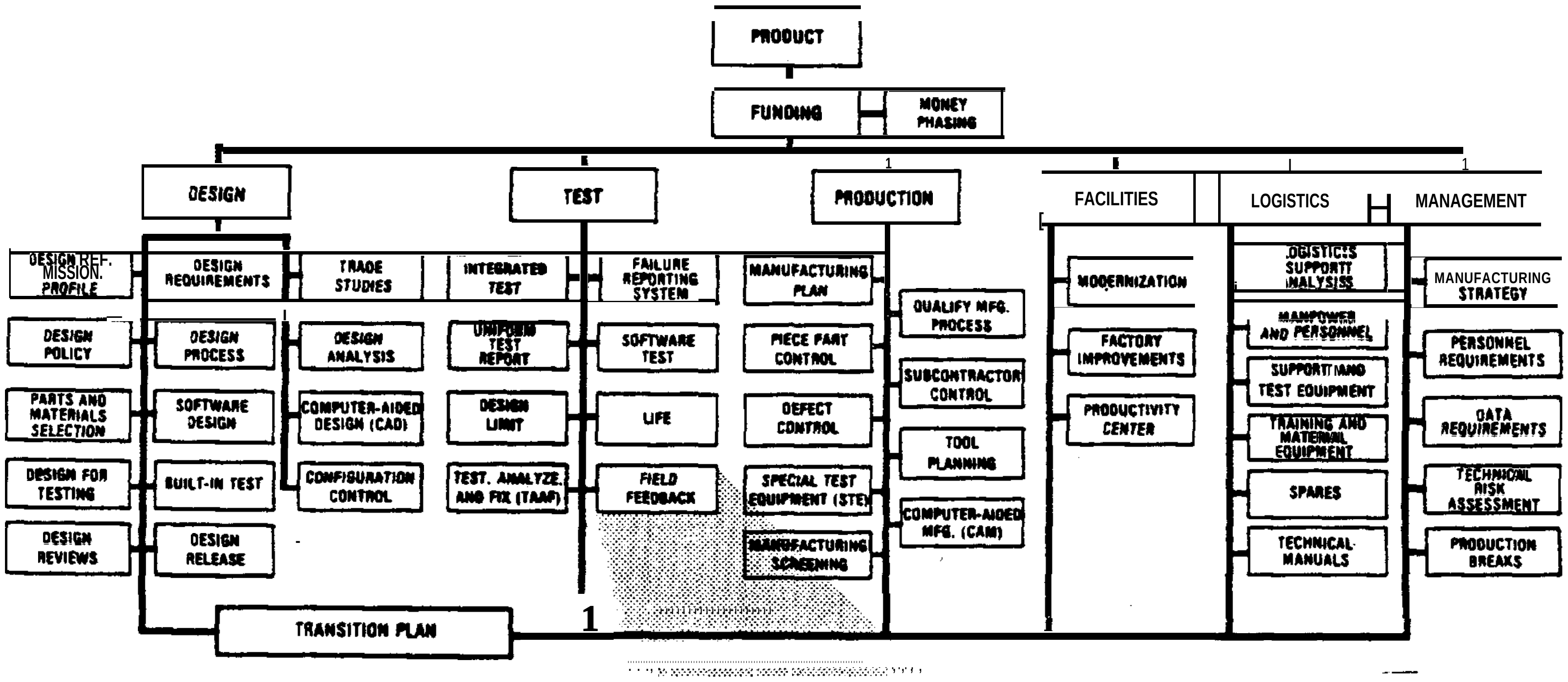



## FIELD FEEDBACK

## AREA OF RISK

Early feedback of problems occurring during initial use of weapon systems is essential for the elimination of unforeseen design defects and correction of problems. Feedback of field problems, however, is slow and inadequate, and failed parts are not returned for analysis in a timely manner. Onsite engineering teams can provide adequate reporting and return of parts, but the usual contractual approach to the use of the teams is to address implementation at contractors' facilities onfy and not to include provisions for service use at remote sites.

## OUTLINE FOR REDUCING RISK

- Weapon systems' contracts provide for an onsite engineering team to observe initial operation, help in identifying problems, provide early feedback of field problems, and provide sufficient data to allow design changes or improvements to the manufacturing process. The duration of this service is established during contract negotiations.

  - The types of problems encountered in initial service operation of new weapon systems require engineering solutions.

  - Solutions are enhanced significantly by onsite engineering analysis.

  - Experience has demonstrated the effectiveness of the onsite analysis process in improving field reliability of weapon systems.

  - The final payoff of the onsite engineering team is the improved reliability of the system during service operation. This is illustrated in figure 4-5. for a recent fighter aircraft program. The reliability problems identified in service use contributed the major part of the observed improvement in mean flight hours between failure (MFHBF) and reduction in discrepancy reports.

– The onsite team is trained adequately.

– Direct communication link is maintained with the design team.

- Onsite engineering teams are not used on small programs where the risk is low. Judgment is required for effective use.

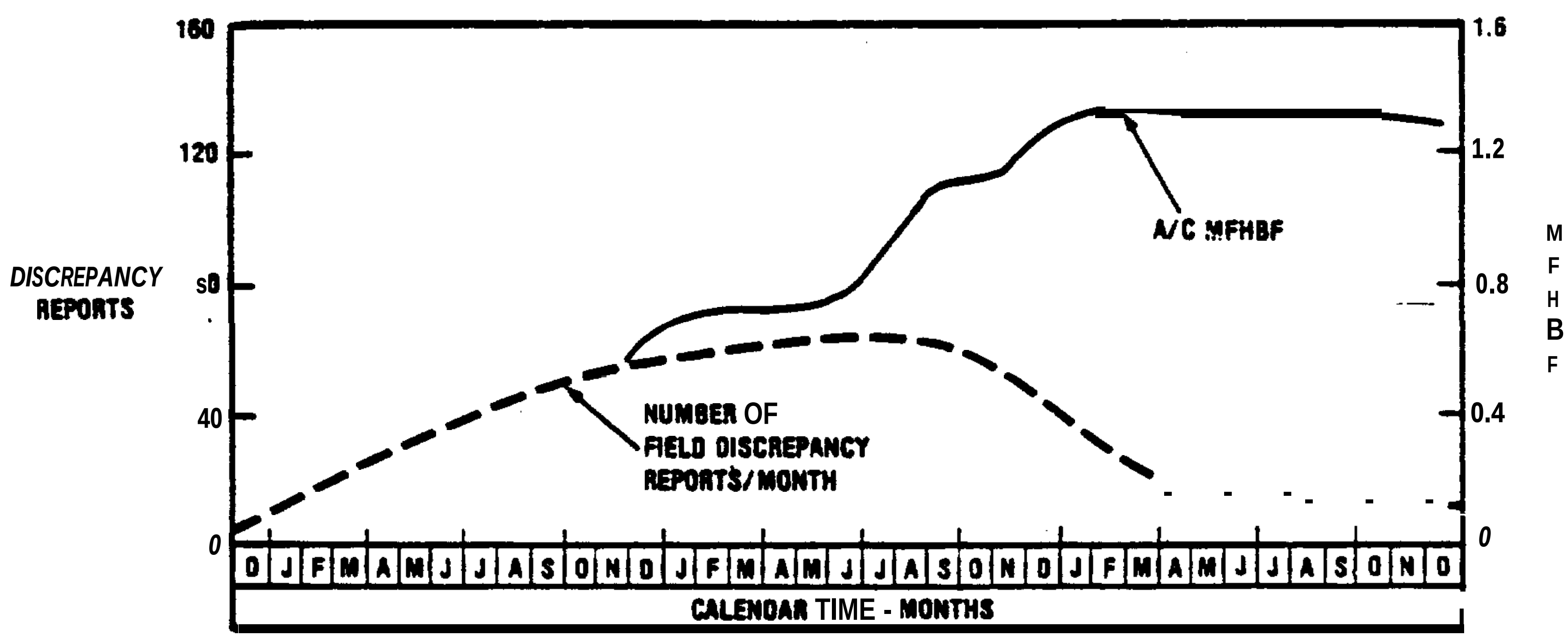
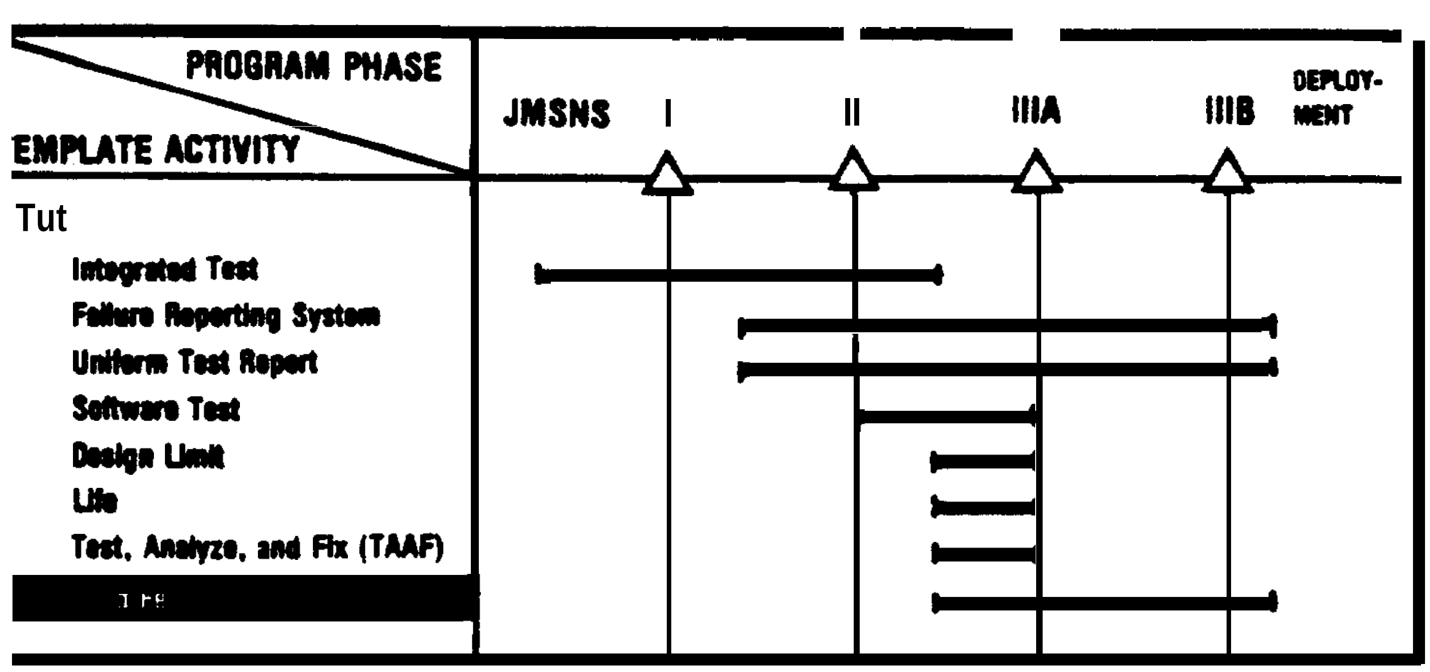



Figure 4-5. Typical Aircraft Service Transition Services

## TIMELINE




Early feedback of problems occurring during initial use of weapon systems is essential for elimination of unforeseen design defects and correction of problems caused by the transition to-full rate production and tooling. Onsite engineering teams are used as soon as field operations begin and continue through service use to improve the accuracy, quantity, and speed of reporting of field failures and corrective actions.

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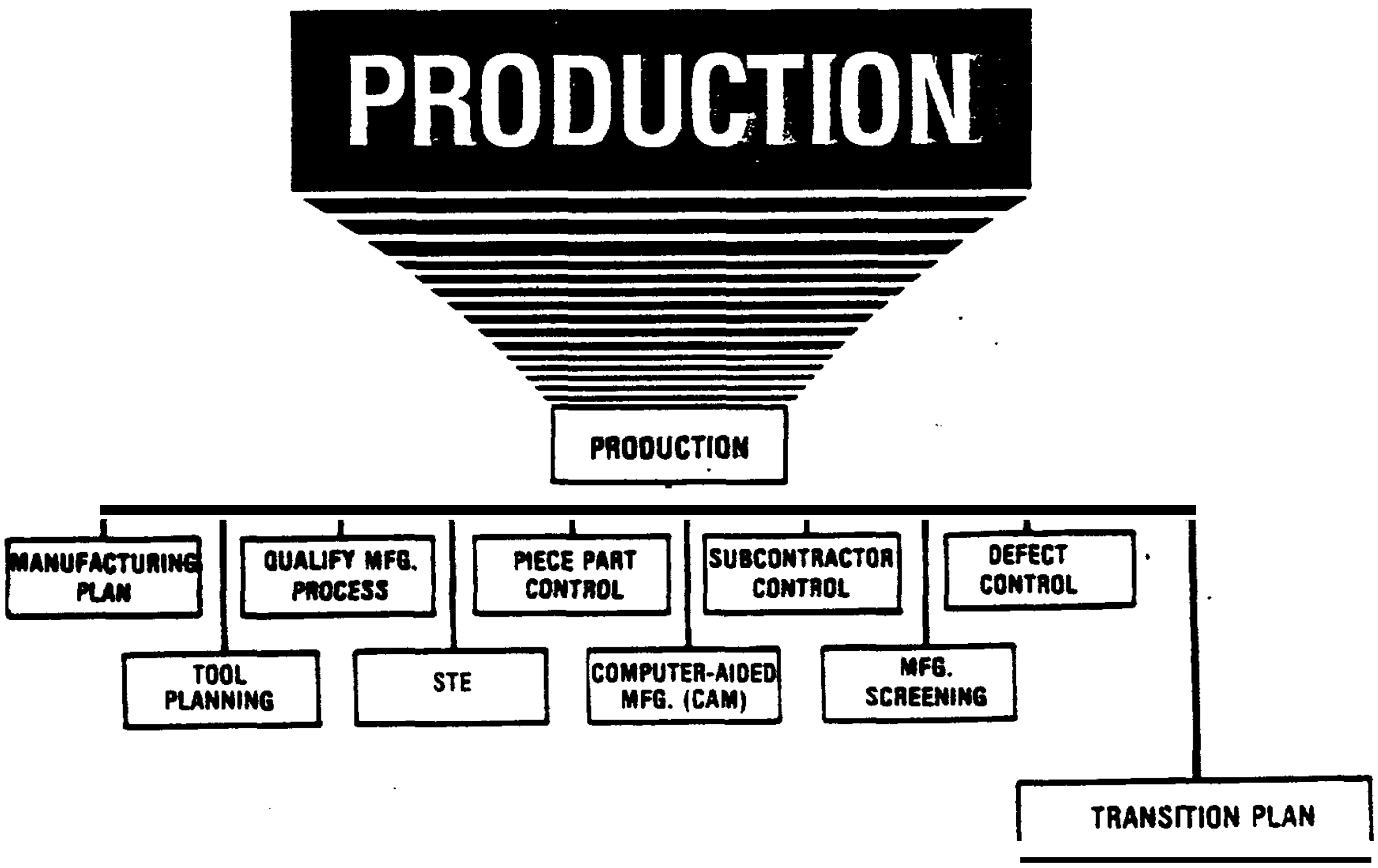
PRODUCTION
PRODUCTION
MANUFACTURING PLAN
TOOL PLANNING
QUALIFY MFG. PROCESS
STE
PIECE PART CONTROL
COMPUTER-AIDED MFG. (CAM)
SUBCONTRACTOR CONTROL
MFG. SCREENING
DEFECT CONTROL
TRANSITION PLAN

# CHAPTER 5

## INTRODUCTION FOR PRODUCTION CRITICAL PATH TEMPLATES

Solving the manufacturing portion of the equation is a major factor in reducing the risk of transition from development to production. The history of military procurements chronicle again and again the scenario of proven functional designs being introduced into the manufacturing process, only to complete that process as end products that cannot support their mission requirements.

The DSB task force investigated transition matters related to preparation for and management of the manufacturing process. More specifically, it dealt with issues in such areas as part quality and management; the cause and relation of workmanship defects; the vendor impact on quality, cost, and schedule; the recipes for successful transition to production; and the associated transition management techniques. The task force agreed that within industry today there exists the experience, wisdom, tools, and techniques to successfully manage the transition process. However, based on past transition experience, the issues outlined in this section represent those that have been especially troublesome and require special initiatives and discipline to manage effectively. Consequently, the implementation of the' concepts, techniques, and procedures specified in this section will. reduce significantly, the risk of transition from development to production.

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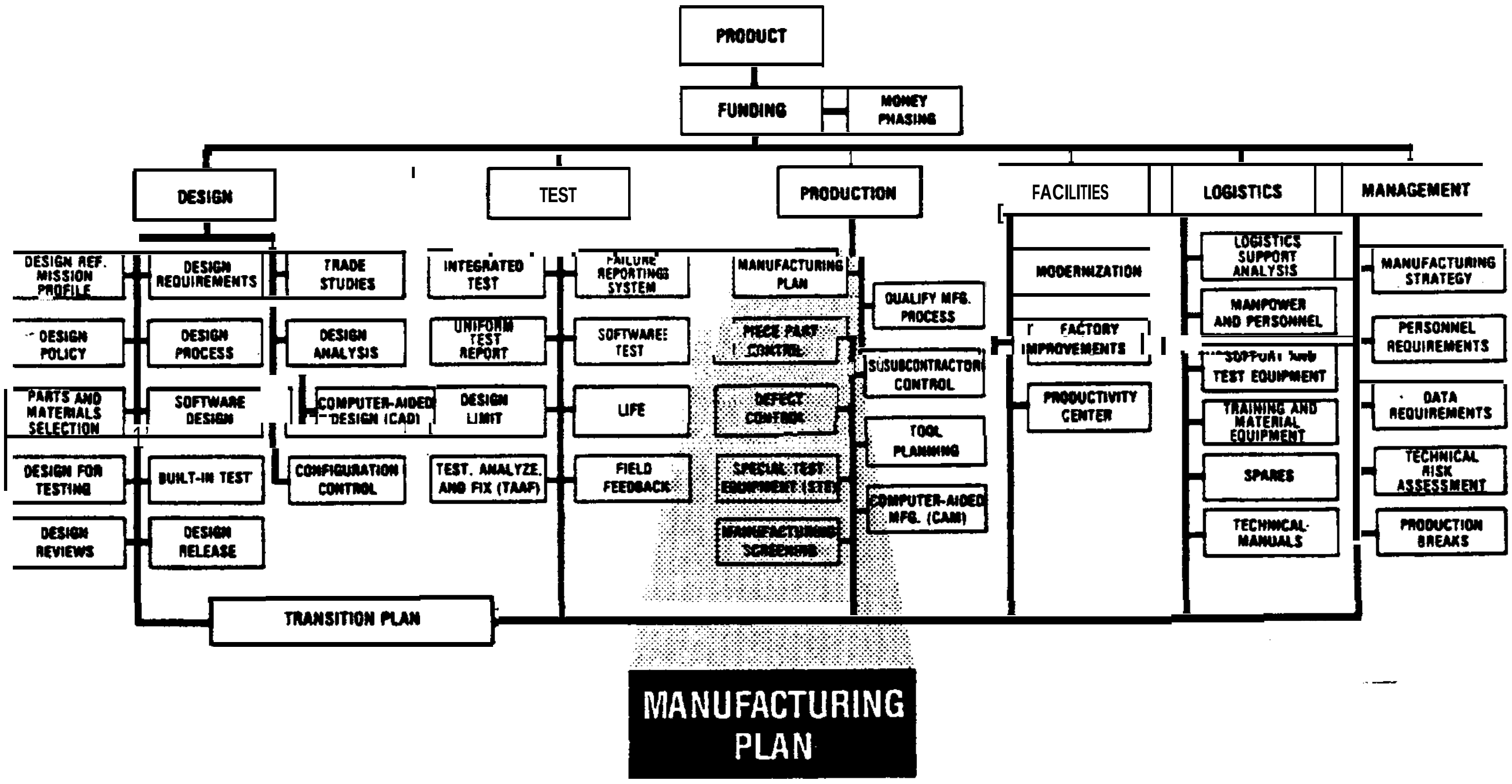



## AREA OF RISK

Involvement of production and manufacturing engineering only after the design process has been completed is a fundamental error and a major transition risk. Consequences of late involvement are (1) an extended development effort required for redesign and retest of the end item for compatibility with the processes and procedures necessary to produce the item, and (2) lower and inefficient rates of production due to excessive changes in the product configuration introduced on the factory floor. Increased acquisition costs and schedule delays are the result of this approach.

## OUTLINE FOR REDUCING RISK

- Documented early planning that focuses on the specifics of the fabrication practices and processes required to build the end item is initiated while the design is fluid and completed before the start of rate production. Documenting this process constitutes a manufacturing plan.

- The following represent the key elements of a manufacturing plan:

  – Master delivery schedule that identifies by each major subassembly the time spans, riced dates, and who is responsible.
  – Durable tooling requirements to meet increased production rates as the program progresses.
  – special tools.
  – Special test equipment.
  – Assembly flowcharts.

- –Test flowchart.
- – Receiving inspection requirements and yield thresholds.
- – Production yield thresholds.
- – Producibility studies.
- – Critical processes.
- – Cost and schedule reports.
- — Trend reports.
- — Inspection requirements.
- – Quality plan.
- – Fabrication plans.
- – Design release plan.
- – Surge and mobilization planning.
- – Critical and strategic materials.
- – Labor relations.
- – Manpower loading.
- – Training.
- – Training facility loading.
- – Production facility loading and capacity.
- – Machine loading.
- – Capital investment planning.
- – Make or buy criteria.
- – Subcontractor and vendor delivery schedules.
- – Government-furnished material demand dates.
- - Work measurement planning.
- – Energy management audits.

● *The* following elements also may be considered when generating a manufacturing plan. They usually are influenced by unique aspects of the acquisition, capabilities of the contractor, or initiatives of the military procurement agency.

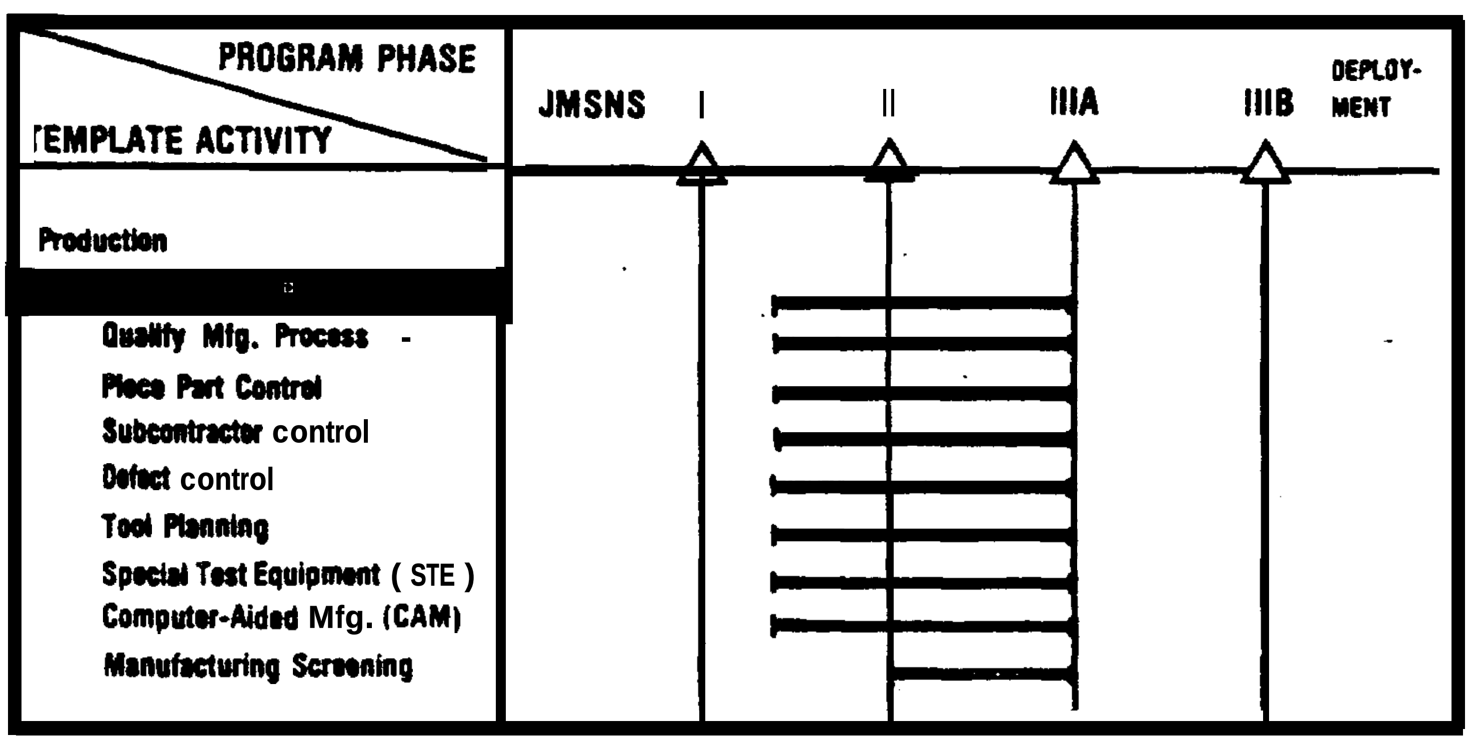
- – Project and functional personnel in manufacturing are collocated.
- – Engineering and manufacturing test equipment are built alike.
- – Assembly planning is verified before rate production.
- – Specify that a part of design engineers' time be spent on the factory floor.
- – Assembly, inspection, test, and rework are mmbined in unit work cells, when appropriate.
- - Development hardware is inspected by production line inspectors.
- - Production personnel participate in building development hardware.

- The overall manufacturing strategy developed earlier in the acquisition cycle is implemented by production planning activities.

- The manufacturing plan is verified and progress against the plan is monitored by a series of contractual and internal production readiness reviews.

  - Reviews include both prime contractor and subcontractor. It is the prime contractor's responsibility to ensure that production readiness reviews are conducted at the subcontractor's facility.
  - These reviews are staffed with knowledgeable personnel (that is, a mixture of manufacturing and design engineering people from outside the line organization doing the work).
  - The depth of these reviews is similar to that of the design reviews with participation by a similar level of qualified people in the areas of design and manufacturing engineering.

## TIMELINE




The manufacturing plan identifies the approach for effective fabrication of the product design. Manufacturing planning activities, concurrent with development activities, are essential.

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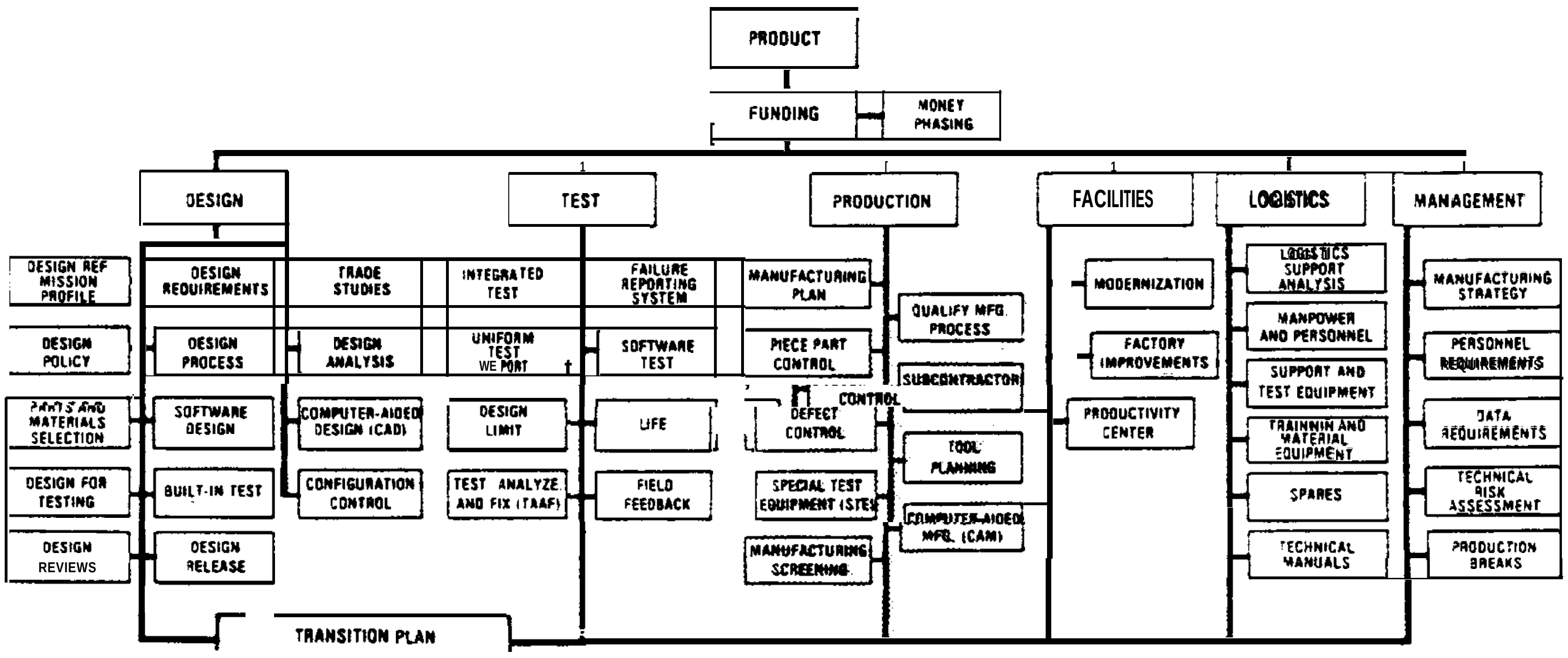



## QUALIFY MFG. PROCESS

AREA OF RISK

The introduction of a recently developed item to the production line brings new processes and procedures to the factory floor. Changes in hardware or workflow through the manufacturing facility increase the possibility of work stoppage during rate production. Failure to qualify the manufacturing process before rate production with the same emphasis as design qualification-to confirm the adequacy of the production planning, tool design, manufacturing process, and procedures-can result in increased unit costs, schedule slippage, and degraded product performance.

OUTLINE FOR REDUCING RISK

- The work breakdown structure, production statement of work (as identified in the contract), and transition and production plans do not contain any conflicting approaches. Any discrepancies among these documents are identified and resolved before production is started.
- A single shift, 8-hour day, 5-day workweek operation is planned for all production schedules during initial startup. Subsequent manpower scheduling is adjusted to manufacturing capability and capacity consistent with rate production agreements.
- The drawing release system is controlled and disciplined.
  - — Manufacturing has the necessary released drawings to start production.
  - – No surge in engineering change proposal (ECP) traffic from design or producibility changes occurs.

—"Block changes" to the production configuration are minimized. (A consistent configuration that does not need any block changes is an indication of low risk.)

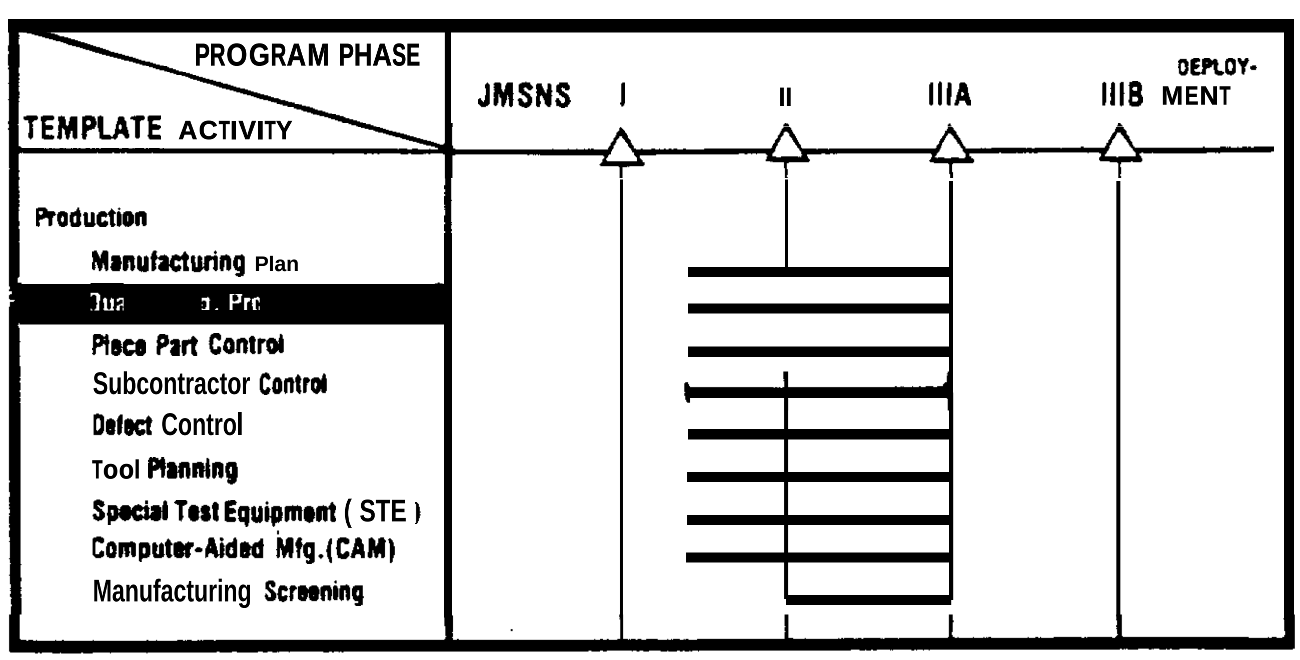
- The manufacturing flow minimizes tooling changes and machine adjustments and ensures that alternate flow plans have been developed.
- A mechanism is established that ensures the delivery of critical, long lead time items 4 to 6 weeks before required.
- All new equipment or processes that will be used to produce the item are identified.

-Qualified/trained personnel are assigned to operate the new equipment and processes.

—"Hands on" training is accomplished with representative equipment and work instructions. (See Productivity Center template.)

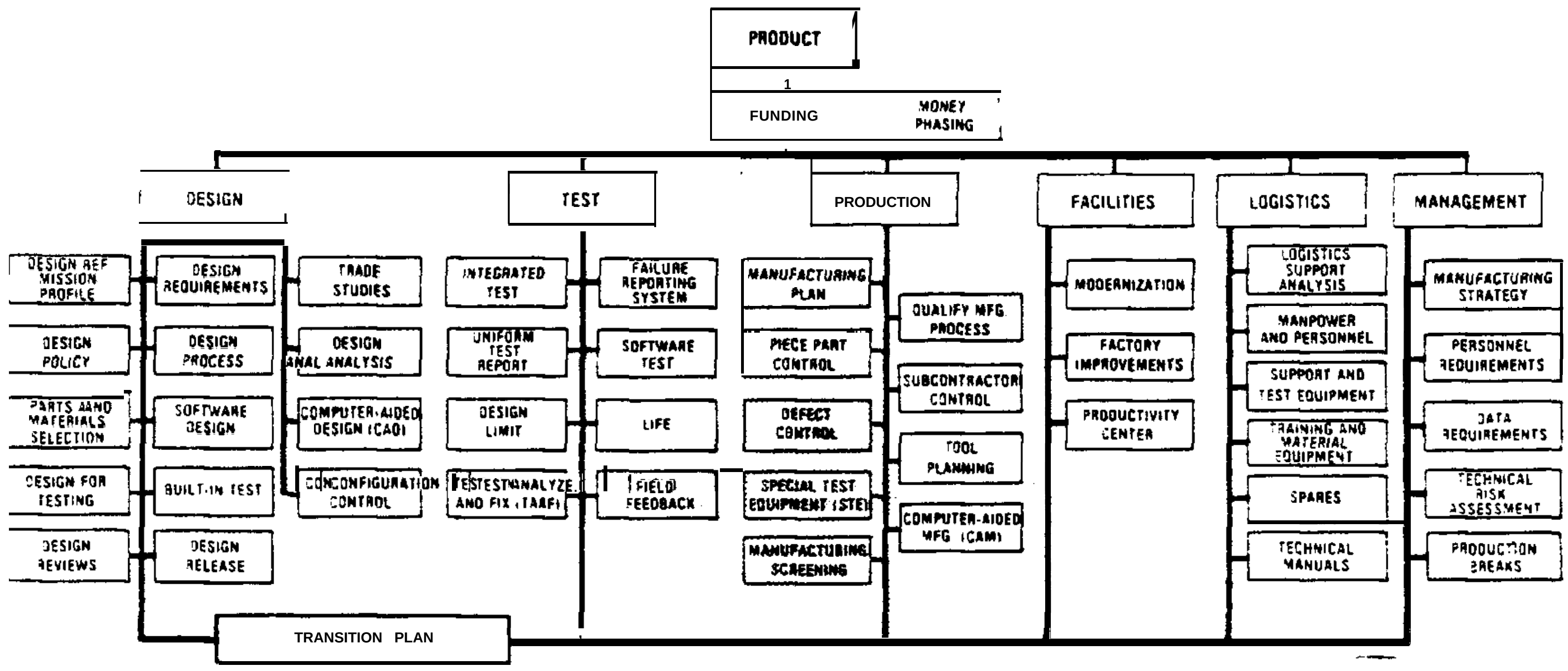
- Hardware and other resources are allocated to "proof of design" models for data package validation, and to "proof of manufacturing" models for implementation prove-out and production equipment troubleshooting. Quantities of the "proof of" models are decided jointly by the customer and contractor depending on the nature and complexity of the program.
- The manufacturing process is qualified both at prime contractors and all major subcontractors.

TIMELINE




The manufacturing process required to produce an item significantly influences the design approach and product configuration. Therefore, the manufacturing process is qualified with enough time for design or configuration changes to be introduced in the baseline product configuration before low rate production commences.

# TEMPLATE




## PIECE PART CONTROL

AREA OF RISK

Most military programs require MIL-STD parts in weapon and support systems. This practice has left much to be desired in its ability to ensure delivery of high quality, reliable parts to contractors. In self-protection, users must conduct intensive screening and inspection at their own facilities, to provide an acceptable product to the production line. Semiconductors in particular have played a major role in increasing the cost and risk of producing a reliable product, in some cases showing defect rates of 3 to 12 percent during user rescreening.

OUTLINE FOR REDUCING RISK

- Receiving inspection is more effective than source inspection:
  - —Suppliers tend to ship better quality products to customers performing receiving inspection rather than source inspection.
  - —Receiving inspection costs typically are less than source inspection.
  - —Typically, more lots per man-hour can be inspected at receiving than at source inspection.
- One hundred percent rescreening of semiconductors reduces risk and usually is cost-effective. Departures from 100 percent rescreening are appropriate, provided they are supported by sound technical and cost rationale. Factors influencing a departure might include the use of mature technology parts, demonstrated ability of the supplier to deliver consistently quality products, and test and failure cost data.

The following represents a minimal baseline program to be conducted at the user's facility:

– Perform particle induced noise (PIN) testing, at a minimum, on all hybrids and preferably on all semiconductors with cavities when used in critical applications.

– Perform electrical test at – 55°C, + 25°C, and + 125°C.

*Typical* costs (1982 dollars) for the above tests:

| | |
|---|---|
| – Transistor/transistor logic (TTL) integrated circuits | $ .68 |
| – Complimentary metal oxide semiconductor (CMOS) logic integrated circuits | .81 |
| – Linear integrated circuits | 1.04 |
| – Memories/microprocessors | 1.45 |
| – Transistors/diodes | .74 |

Typical costs (1982 dollars) for parts replacement if the defect is found at a higher level of assembly:

| | |
|---|---|
| – Printed wiring assembly | $ 50 |
| – Line replaceable unit | 500 |
| – System | 1.500 |
| – Field | 15,000 |

- Performing destructive physical analysis (DPA) at the user's facility also can detect faulty parts, can verify suppliers' processes, and is a good adjunct to the rescreening program.

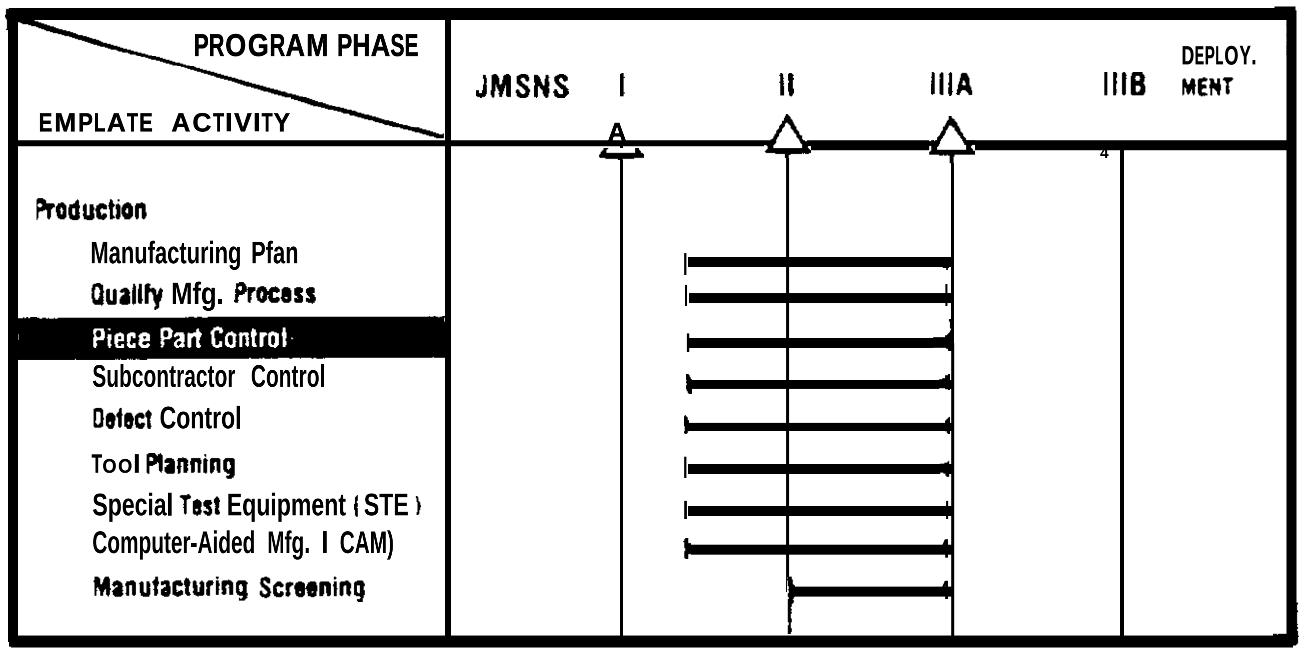
- Small users can use an independent test laboratory to conduct rescreening if they lack the necessary test equipment. Costs *to* conduct this screening are similar to those quoted above.

- Receiving inspection and rescreening exert contractual leverage on part suppliers to improve overall quality of the product and ultimately to reduce the cost of parts to the user.

- Pretin component leads and conduct a solderability test at incoming inspection.

- Piece part control includes provisions for screening of parts (especially mechanical and electrical components, as well as electronic devices), to ensure proper identification and use of standard items already in the Military Service logistics system.

## TIMELINE




A key element of parts control is an established policy that ensures that certain steps are taken early in the buildup of the first hardware items to control part quality (both electrical and mechanical).

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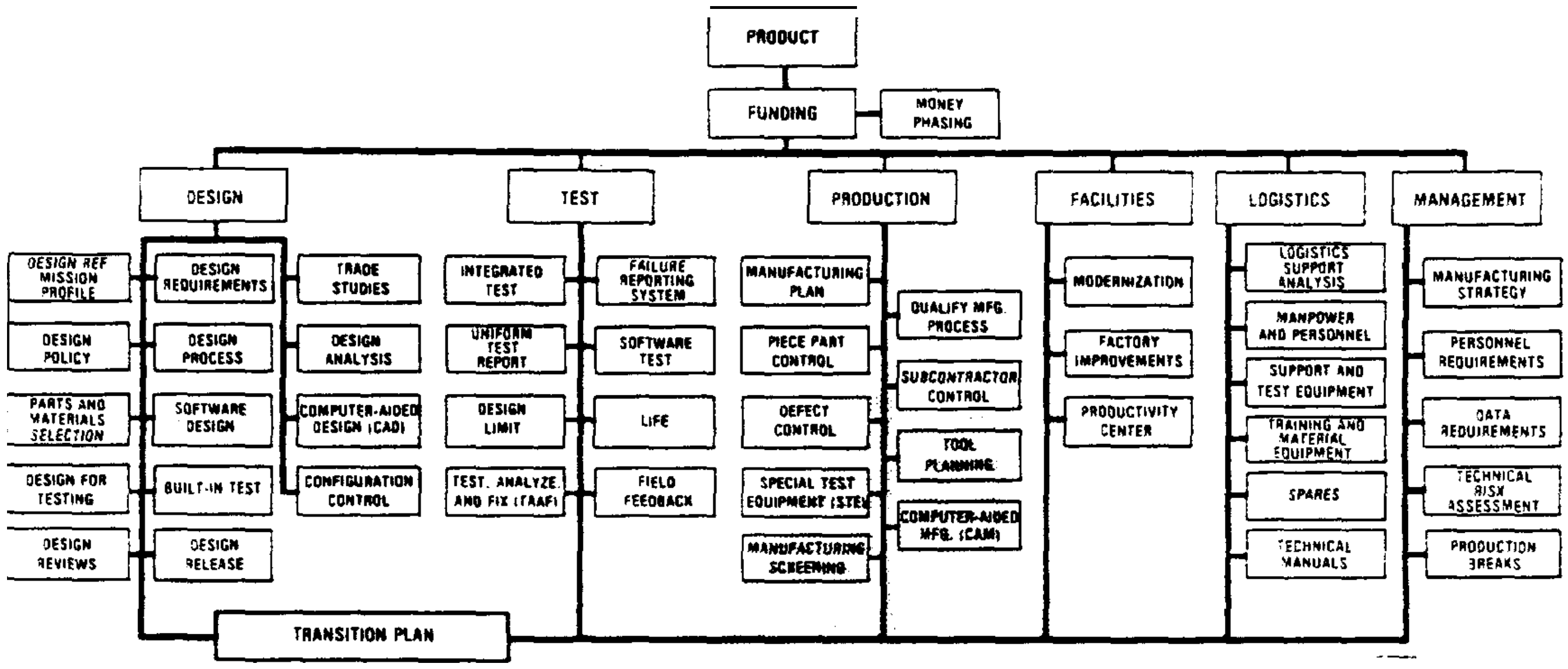



## SUBCONTRACTOR CONTROL

AREA OF RISK

Over the years, the percentage of major weapon systems that are subcontracted has grown, reaching as much as 80 percent in some cases. Hence, reliance on subcontractors and upon the skills of prime contractors to manage their subcontractors and suppliers has increased. An informal poll of ten prime contractors averaging about ten major programs each resulted in statements that nearly half their programs were in schedule or cost trouble because of major subcontractor problems. Clearly, the effective management of subcontractors needs more emphasis within industry and in the Government's management of prime contractors if there is to be a smooth transition to production.

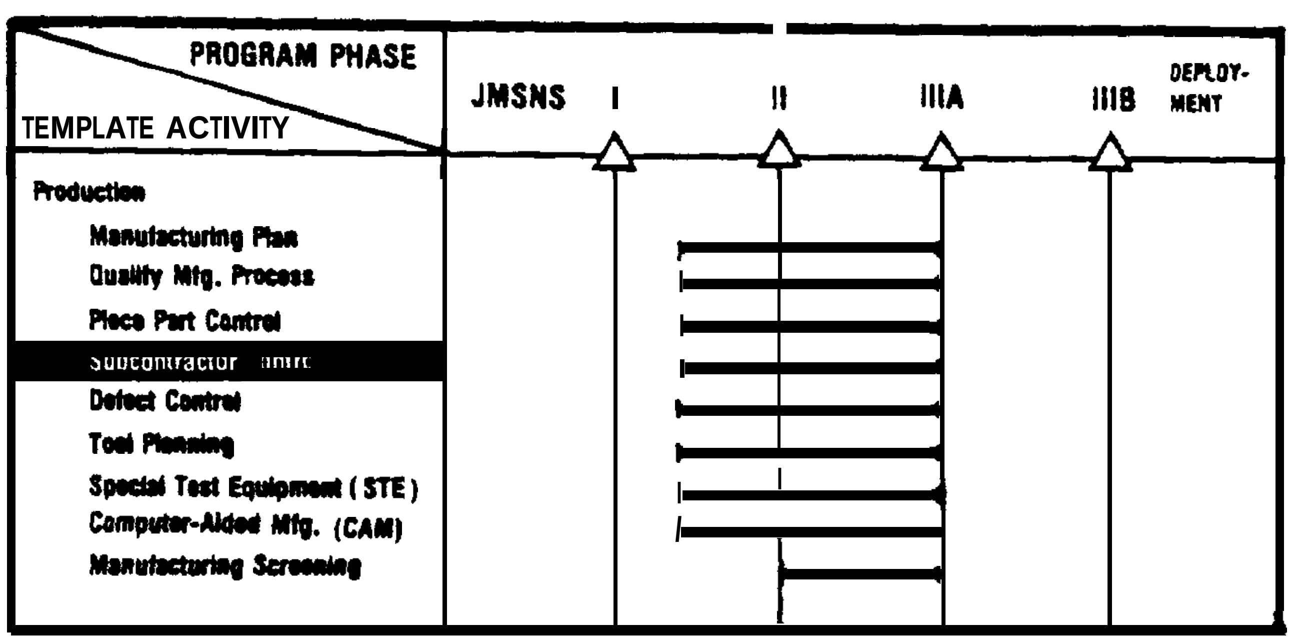
OUTLINE FOR REDUCING RISK

- Request for proposals (RFPs) for prime contractors require responses from bidders with equitable emphasis on subcontractor management planning versus in-house management. Responses include the following:
  - Prime contractor's organization for managing subcontractors.
  - Plans for onsite evaluation of potential subcontractors before source selection.
  - Tasks and associated payment plans to ensure that required up-front "subcontractor activities are visible.
  - Plans for program reviews, vendor audits, and production readiness reviews.
- Military program managers and prime contractors conduct vendor conferences that address the following:

- Educate each subcontractor thoroughly on the requirements in his or her contract, as well as the key elements of the prime contract.
- Communicate to the subcontractors what is required of them.
- Provide an awareness of their role in the total weapon system acquisition.
- Allocate resources to do the job right.
- Recognize and (when appropriate) reward good performance.

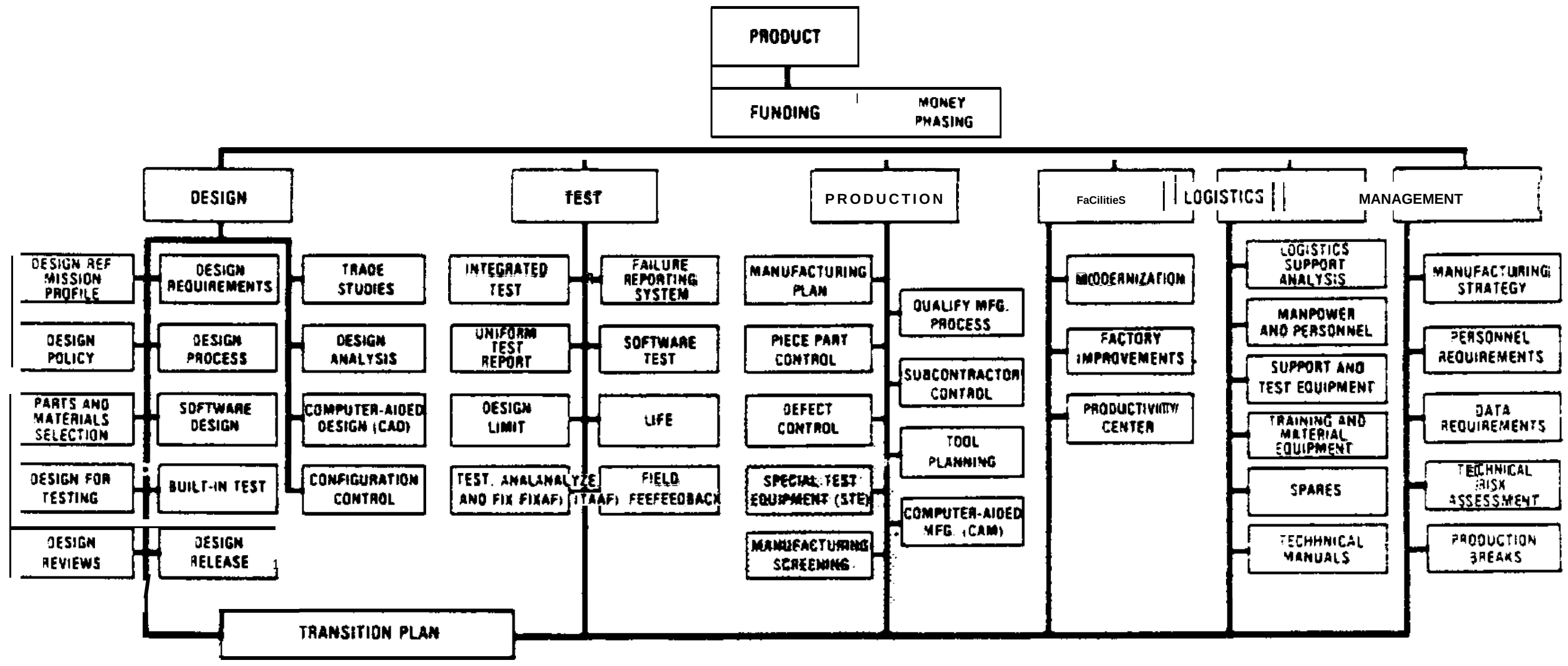
- prime contractors establish resident interface at critical subcontractors before production start.
- prime contractors maintain a roster of "subcontractor assist" personnel for surprise problems.
- Budget for both resident and "subcontractor assist" teams to be available on demand with well-qualified technical, process, manufacturing, and procurement people.
- Proper funding is committed to conduct the above guidelines during the early design phases, to ensure adequate support to procurement. An estimate for an 80 percent subcontracted' program amounts to 3 to 4 percent of full-scale engineering development costs.

## TIMELINE




Informal and formal program reviews are an essential ingredient of effective subcontractor control during the development process. The prime contractor shall, *on* a regular basis, evaluate the "real" progress made by the subcontractor through such reviews.

# TEMPLATE




**DEFECT CONTROL**

AREA OF RISK

High defect rates in a manufacturing process drive up production costs because of higher rework and scrap costs. Product quality is a function of the variability of defects, that is, the higher the number of defect types, the lower the quality and vice versa. Lack of an effective defect information and tracking system not only increases production costs but also degrades the product's performance in the field.

OUTLINE FOR REDUCING RISK

- Types of assembly defects are identified in terms of specific data categories and priorities for corrective action. (See figure 5-1., which applies to electronic parts. Similar figures are derived for other categories of component parts.)

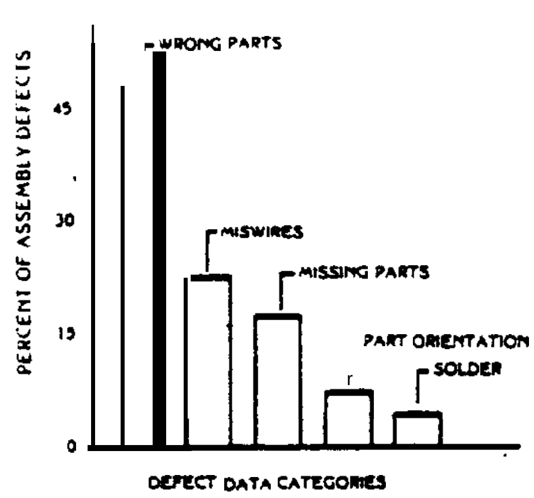



Figure 5-1. Assembly Defects

- Effectiveness of a time-phased corrective action program is tracked (see figure 5-2.)

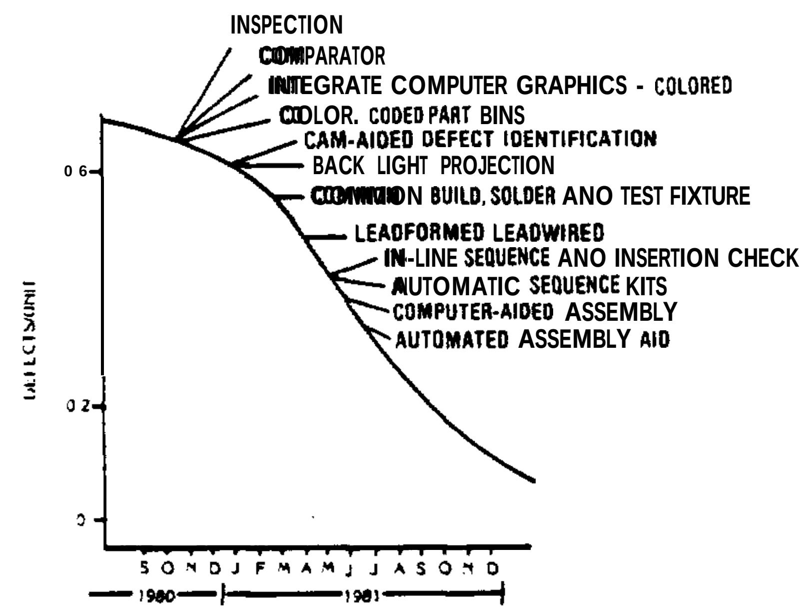



Figure 5-2. Corrective Action Program

- Inspection and test yields and hardware throughputs are monitored continuously with predetermined action thresholds (see figure 5-3.)

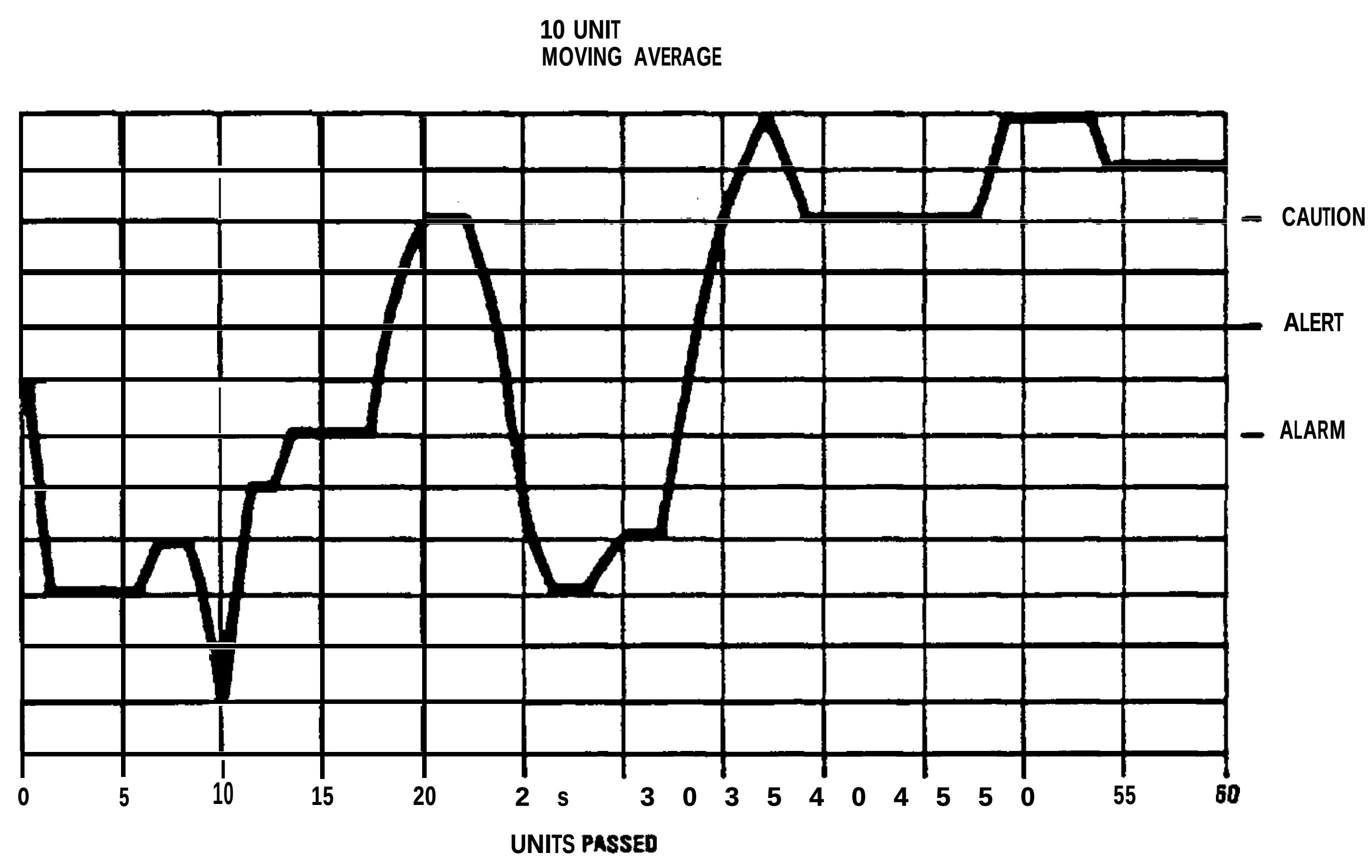



figure 5-3. Performance Threshold Tracking

– Caution threshold requires engineering action:

. seventy-two-hour maximum response time.

- Daily reporting to program management until caution thresholds are exceeded.

– Alert threshold requires functional-level management action:

- Seventy-two-hour maximum response time.
- Daily progress reports to program management until all thresholds are exceeded.

– Alarm threshold requires full-time team action:

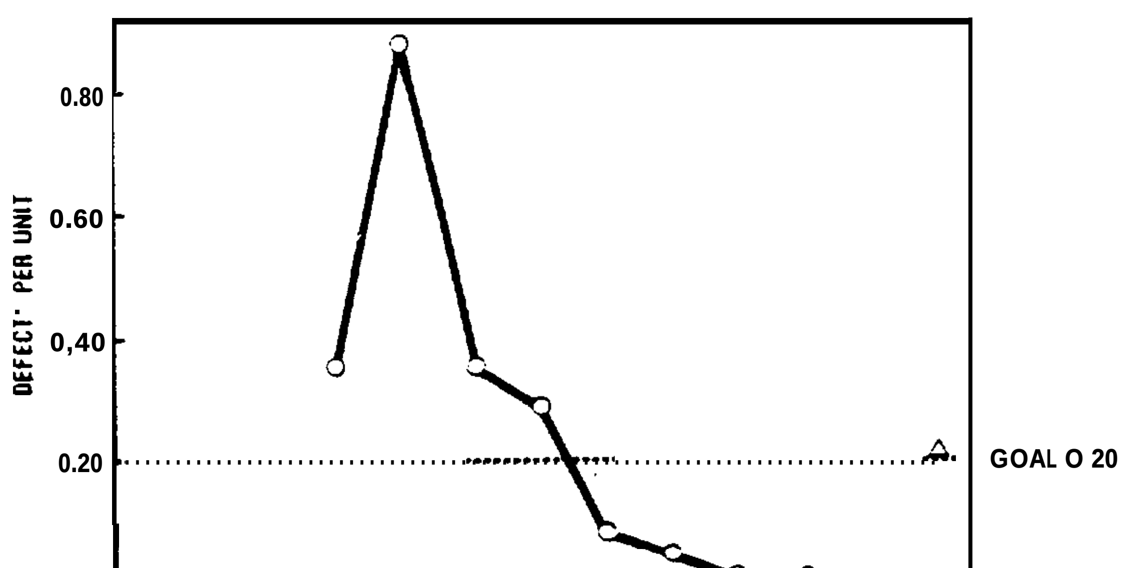
. Program manager constitutes team within 24 hours.

. Action is implemented and reported to program management within 72 hours.

- Daily reports to program management until thresholds are exceeded.
- A feedback system to factory personnel and manufacturing supervisors is established.

. Factory policy adequately reflects the criticality of its defect information and tracking system.

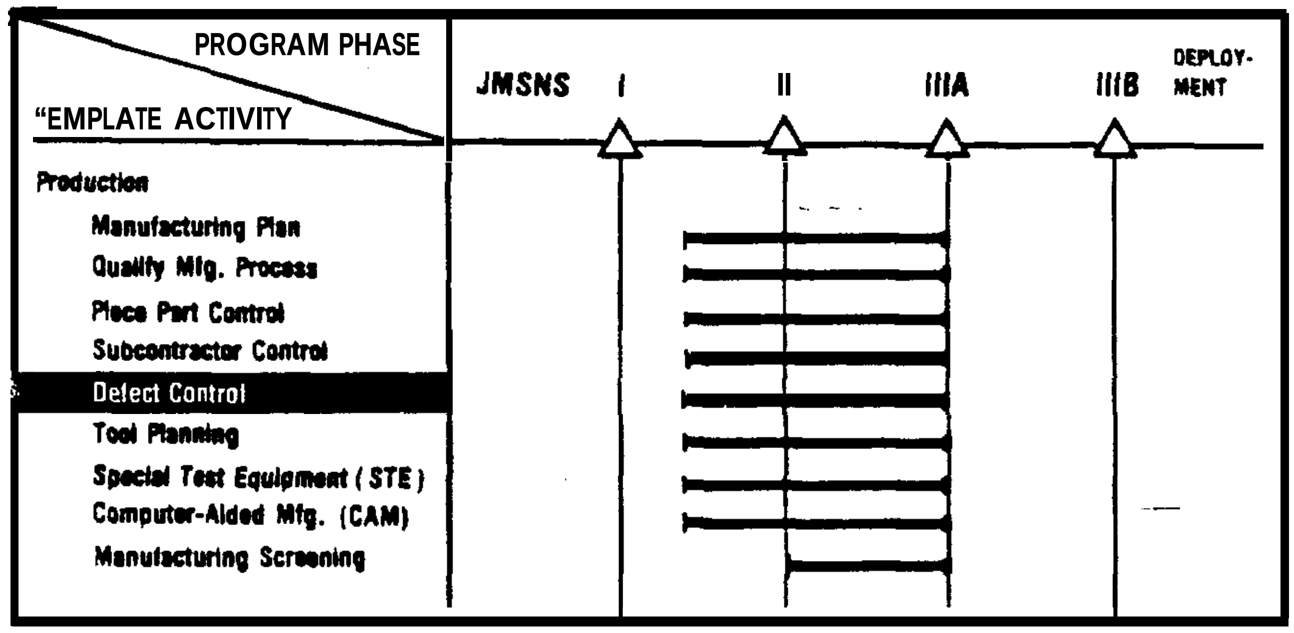
- Critical process yields are monitored and tracked to ensure consistency of perfomtance (see-figure 5-4.)




| | J | F | M | A | M | J | J | A | S | O | N | D | 1982 TOTALS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TESTED | | | | 40 | 54 | 86 | 56 | 75 | 79 | 56 | 91 | 55 | 502 |
| DEFECTS | | | | 14 | 53 | 30 | 16 | 6 | 4 | 1 | 1 | 0 | 125 |
| DPU RATE | | | | 0.350 | 0.981 | 0.349 | 0.286 | 0.080 | 0.051 | 0.018 | 0.010 | 0.000 | 0.211 |

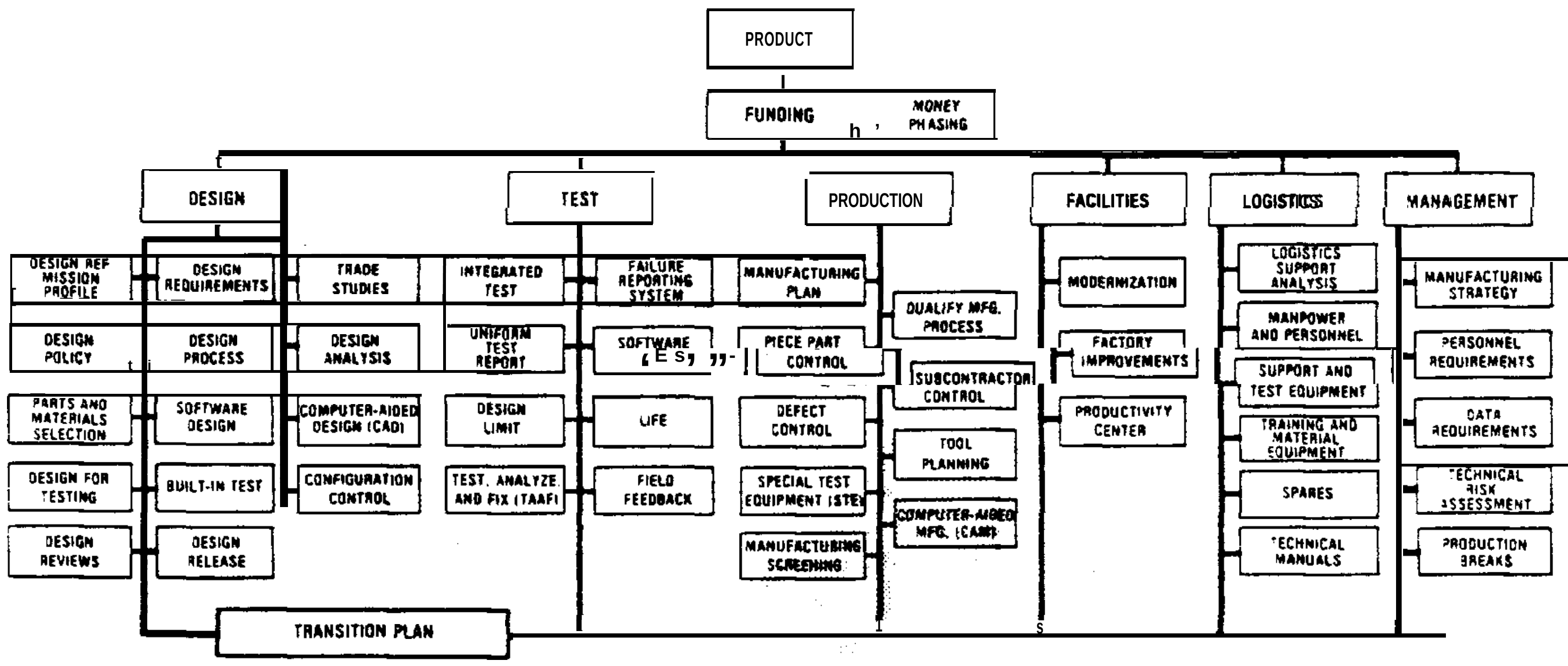
Figure 5-4. Production "Rate Test" Defects

TIMELINE




A management commitment to defect “prevention” is the prime ingredient of a sound defect control program. A management policy on defect control is established during the development phase. This policy will require management involvement in the review of defect analyses and an emphasis on defect “prevention” that is flowed down to all subcontractors.

# TEMPLATE




## TOOL PLANNING

AREA OF RISK

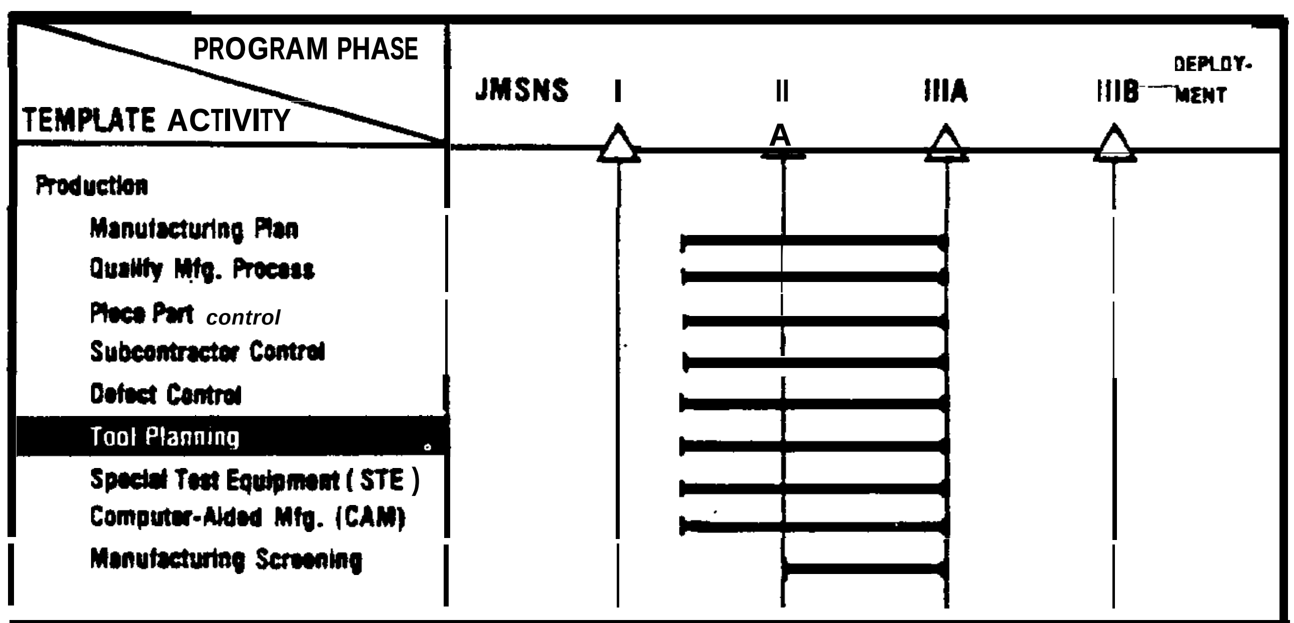
Tools are auxiliary devices and aids used to assist in the manufacturing and test processes. They range from special handling devices to ensure personnel and equipment safety, to equipment required for methods planning to achieve the designed quality, rate, and cost. The risks associated with improper tool planning and proofing affect cost, quality, and ability to meet schedules. Improper tools prevent workers from achieving desired production rates, fail to prevent or perhaps even contribute to errors in the build process, and cause more man-hours of labor to be expended in accomplishing a task than were planned.

OUTLINE FOR REDUCING RISK

- A tooling philosophy is documented as a part of the early manufacturing planning process and concurrent with production design.
- A detailed tooling plan is developed that defines the types "hard" or "soft,", and quantities required for each manufacturing step and process.
- A requirement is included for a similar plan for each subcontractor and its implementation is disciplined.
- Each tool is proofed rigorously before its initiation into the manufacturing process to verify performance and compatibility with its specification.
- Strict tool configuration management is maintained.

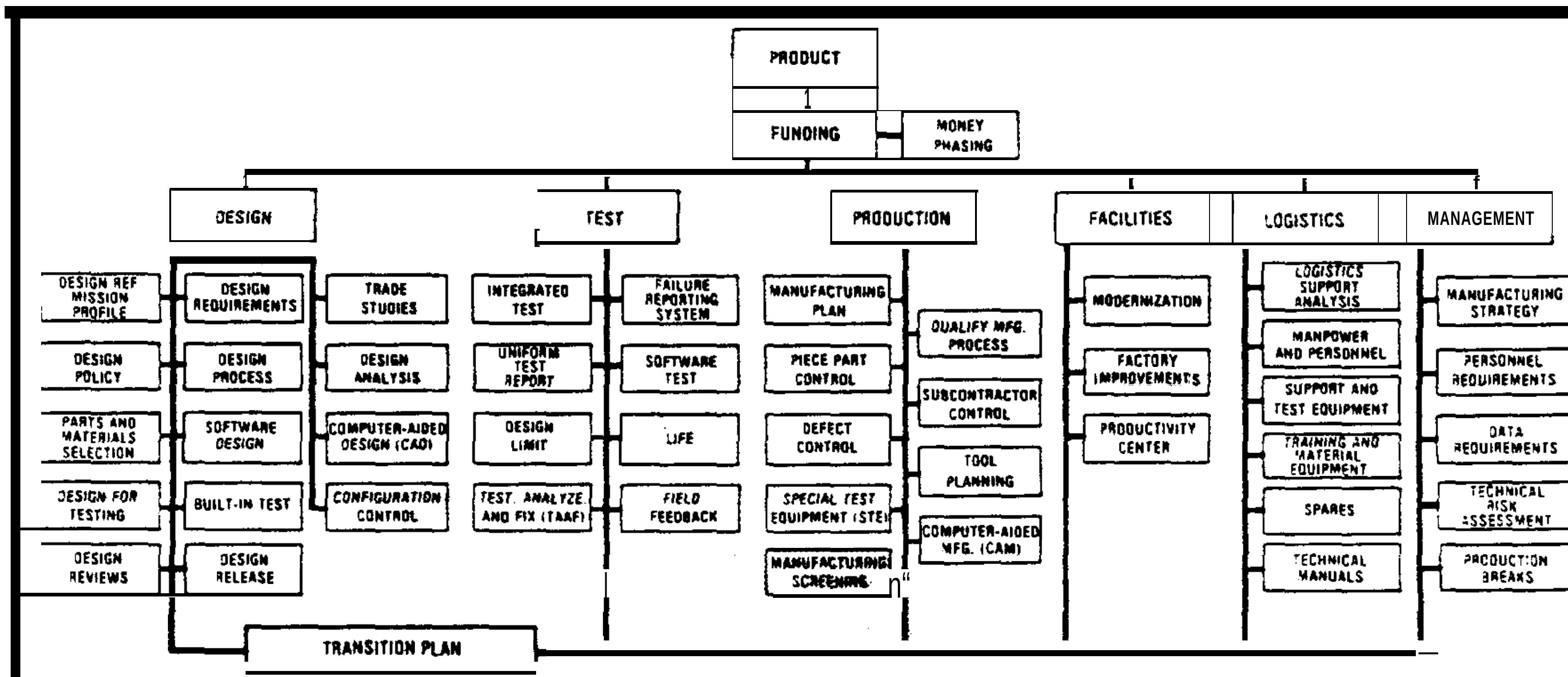
- An effective tooling inventory control system is established and maintained to facilitate continuous accountability and location control.
- A routine maintenance and calibration program is established and conducted to maintain tool serviceability.
- Manufacturing engineering and tool designers are collocated with design engineers when practical, and CAD/CAM systems are used in tool design and fabrication.

TIMELINE




Tool planning encompasses those activities associated with establishing a detailed comprehensive plan for the design, development, implementation, and certification of program tooling. Tool planning and design activities start early in the development phase.

# TEMPLATE




## SPECIAL TEST EQUIPMENT (STE)

AREA OF RISK

Special Test Equipment (STE) is a key element of the manufacturing process. It is STE that tests an article (or final product) for performance after it has completed in-process tests and inspections, final assembly, and final visual inspection. Late STE design activities and the lack of the availability of qualified STE on the factory floor create unique technical risks. These risks include inconsistent final test measurements (when compared to test procedures used during the successful development program), false alarm rates that result in needless troubleshooting and rework of production hardware, and poor tolerance funneling that causes either rejection of good hardware or the acceptance of hardware with inadequate performance. Program consequences in this situation are schedule delays, increased unit costs, and poor field performance of delivered hardware.

OUTLINE FOR RISK REDUCTION

- A thorough factory test plan is developed before detailed design of prime equipment.
- Adequate prime equipment designer input and concurrence on test requirements and test approach is required.
- Test equipment engineers and maintainability engineers participate in prime equipment design and partitioning, test point selection, built-in test design, and design for test and maintenance as well as function.
- Prime and STE systems design personnel are collocated when practical.
- The test approach for completeness of test is analyzed, and a feedback loop to correct test escapes is provided.

- Test tolerance strategy is employed to catch problems at the lowest level, but does not cause excessive rejection of an adequate product. Tolerance incompatibility with higher-level test is corrected.

- The capabilities of the prime equipment are understood and utilized fully to achieve simplifications in STE.

- Design strategies are used in test equipment that simplify tolerance changes and enable tests to be readily added and deleted. "Go/no go" tests are minimized.

- Manual intervention capability is provided in automated test equipment so that the equipment can be used while final software debugging is in process (this also can aid in debugging).

- Brassboard prime equipment is used, when appropriate, to begin debugging test equipment (this can enhance test equipment schedules).

- Prime equipment design personnel are assigned' as part of the test equipment integration and verification effort.

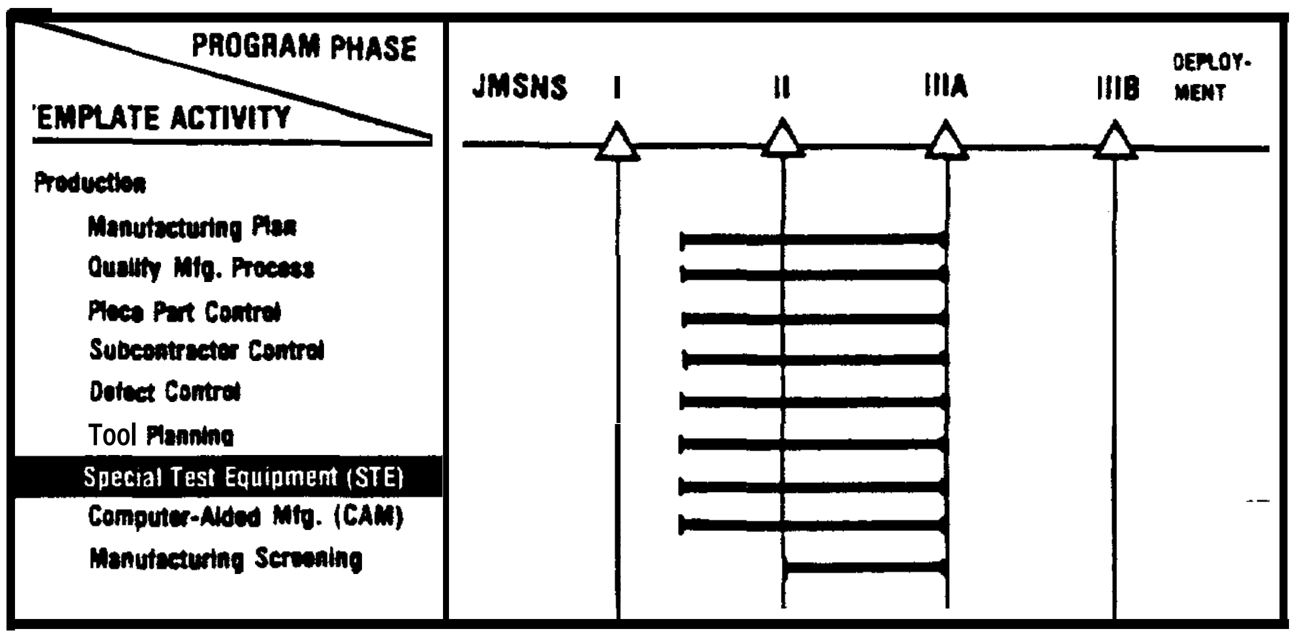
- Adequate time is allotted for test equipment software debugging and compatibility verification.

- Government certification of factory test equipment is required, as well as re-certification if significant product and test equipment changes occur.

- A thorough and realistic rate analysis is performed to avoid shortages of test equipment (or overbuying). Considered in this analysis are the number of expected failures in prime and test equipment in various phases of the program, and equipment requirements to support qualification test, TAAF, engineering problem-solving, and overhaul and repair.

- Automated test techniques are used when rate requirements on the program warrant the investment.

TIMELINE




STE should be designed, qualified, and used as early as possible to ensure a uniform final product test from development through production transition. The STE design should commence during the late phases of advanced development (that is, before Milestone II) and STE should be qualified before rate production.

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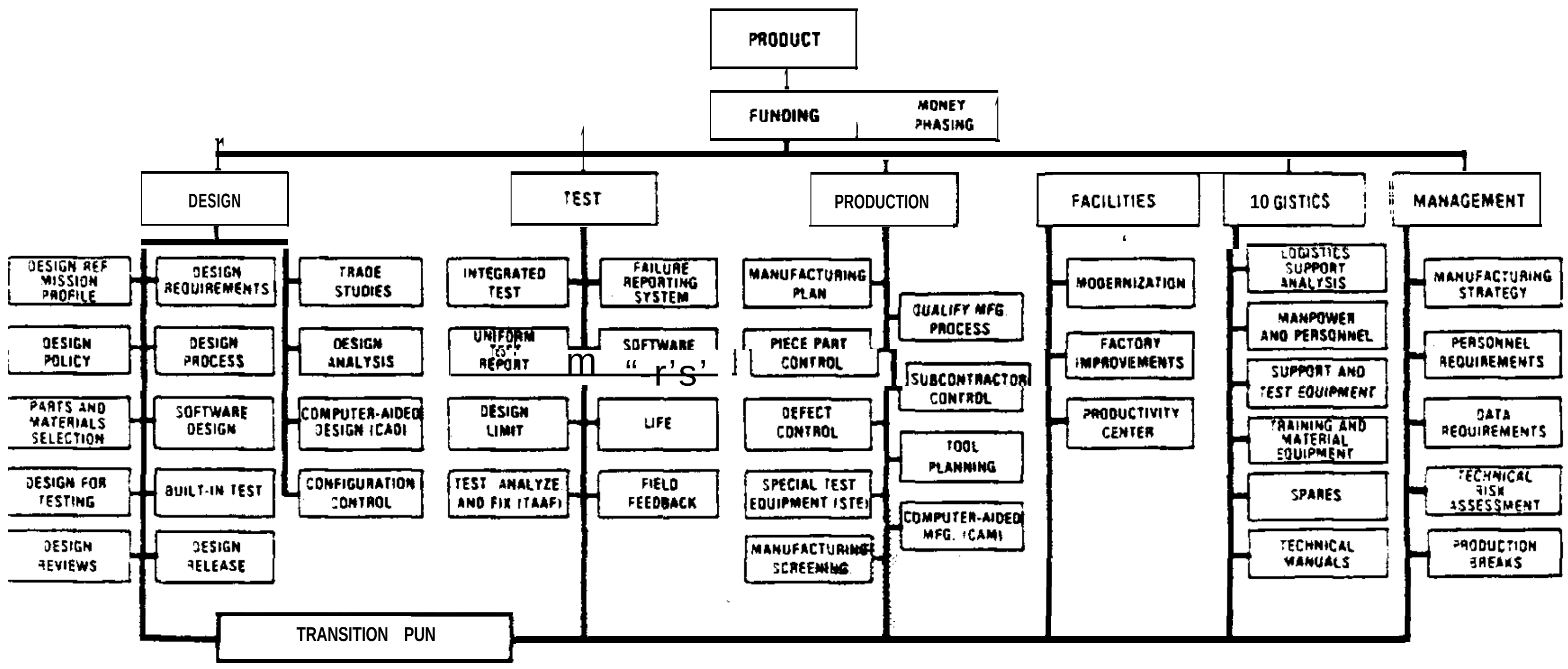



## COMPUTER-AIDED MFG (CAM)

### AREA OF RISK

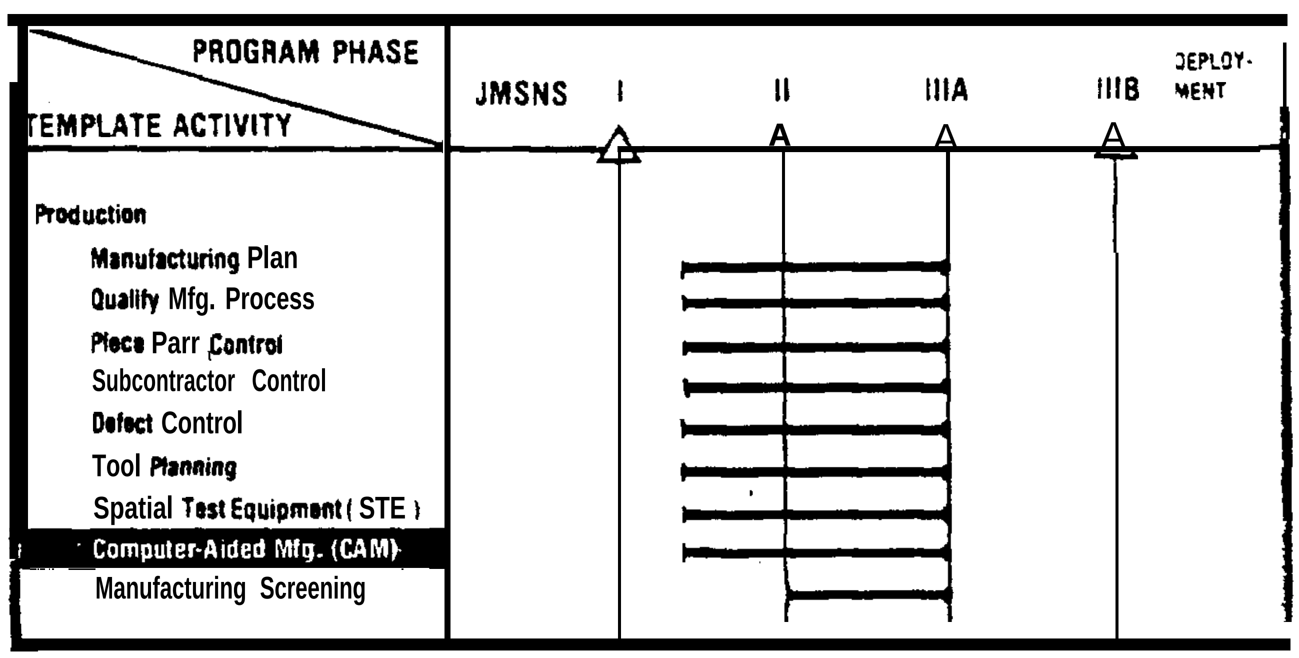
The transition of a qualified design to the manufacturing process historically has been accomplished via a "drawing package," including not only drawings but also a large number of related documents, truly a massive amount of paperwork. Generation of this paper lengthens the period of transition, impedes rapid and accurate communication between the design and manufacturing functions during this highly volatile period, and introduces numerous errors via the drawing package. Even some facilities that have invested heavily in CAD continue to transfer their designs to the factory on paper. Once the drawing package is available, many production facilities continue to utilize outdated high risk manual operations both to duplicate the design ("build to print") in rate production and to manage the manufacturing process.

### OUTLINE FOR REDUCING RISK

- The development of software tools for common use by industry is supported by the Department of Defense with appropriate resources and coordination efforts.
- A common data base between the design and manufacturing functions has inherent technical problems but has the highest potential payoff in product quality and productivity.
- Implementing automated manufacturing and control functions can reduce transition time by 50 percent.
- Using computers to control manufacturing operations (fabrication, assembly, test, and inspection) and to collect shop floor data can increase productivity, can reduce required shop floor space, and can improve product quality.

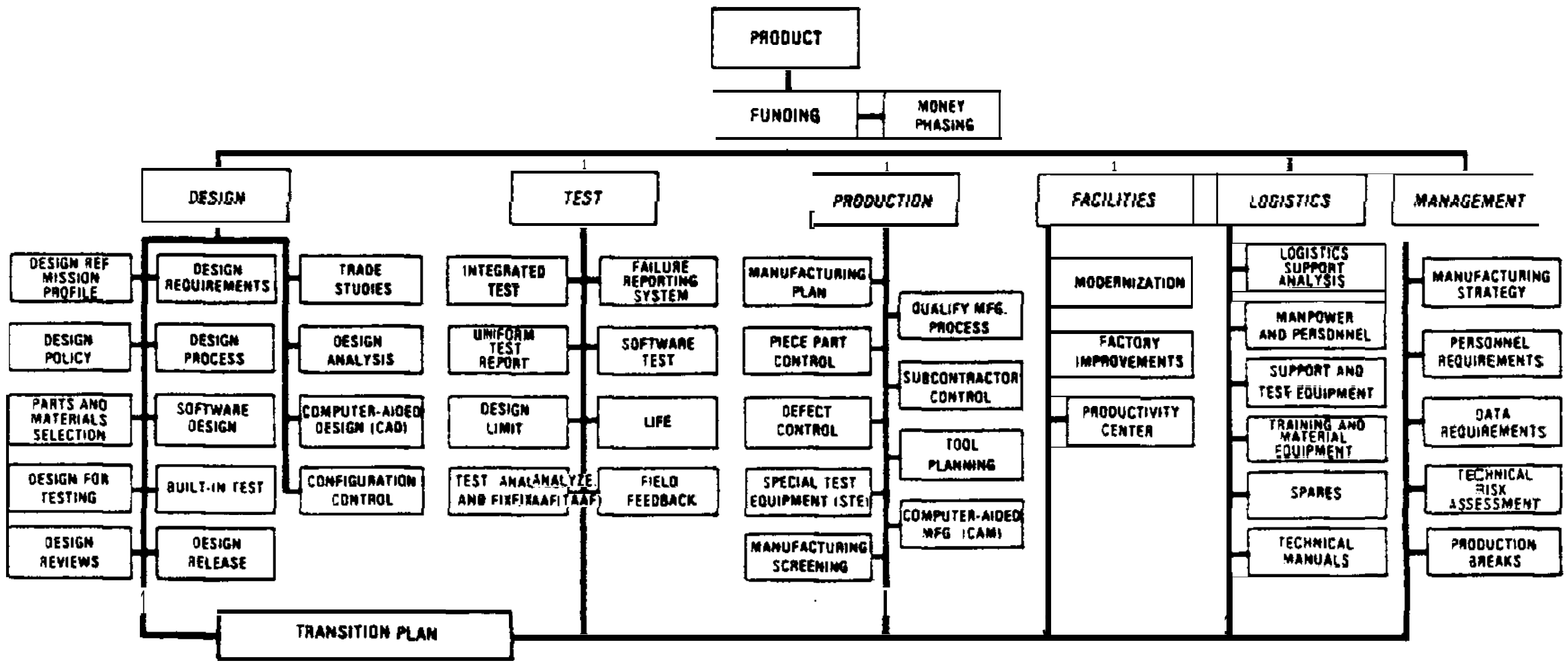
- Use of computers to control material flow and maintain inventory and in-process data significantly reduces inventory investments and storage space.
- Tooling redesign occurs when product design changes. Using CAD reduces these design iterations. Therefore, using CAD for the product design and the additional use of CAD for tool design can reduce tooling costs by 50 percent.
- Top-down strategy for implementing CAM usually increases return on investment (as opposed to replacing in-kind capability, or bottom-up).
- Training and retraining plans to maintain employee morale and productivity are included in a company's strategy.
- See template on CAD.

## TIMELINE




Contractors using CAM integrated with CAD are experiencing improved productivity. With manufacturing personnel involved in the design process, a common CAD/CAM data base can be established resulting in reduced risk in the transition from development to production.

# TEMPLATE




## MFG. SCREENING

AREA OF RISK

Environmental stress screening (ESS) is a manufacturing *process* for stimulating parts and workmanship defects in electronic assemblies and units. Although ESS has been proven to reduce field failure rates by 20 to 90 percent (reducing life cycle costs) and to reduce in-plant failure rates by as much as 75 percent (reducing production costs), its use is *still* not accepted universally by many contractors as a standard part of their manufacturing process. When ESS also is performed during development, it helps to ensure that the electronics hardware performs on demand, that the most effective screening levels are determined before high rate production, and that possible part type and vendor problems are discovered early. Analysis of failures experienced on unscreened developmental systems has indicated that 60 percent are due to workmanship, 30 percent are due to bad parts, and *only 10* percent are design problems. ESS should not be confused with environmental qualification testing (which is designed to demonstrate design maturity).

OUTLINE FOR REDUCING RISK

- ESS procedures are established during development.
- Temperature cycling and random vibration are effective” environmental stress screens and are performed on 100 percent of electronic products (it is not done on a sampling basis).

- The predominant factors in temperature cycling are:
  - Rate of change of temperature.
  - Minimum and maximum range of temperature.
  - Number of cycles.
  - Level of assembly on which performed.

- The predominant factors in random vibration are:
  - Spectral density.
  - Lower and upper frequency limits.
  - Axis of stimulation.
  - Level of assembly.
  - Duration of screen.

- Random vibration stimulates more defects than fixed or swept sine vibration of similar levels of excitation.

- There are many technical and cost benefit tradeoffs to be made in designing an ESS program. A particularly useful document in making tradeoff decisions is the Environmental Stress Screening Guidelines for Assemblies.[1] A screening guidelines document for parts will be published by the IES in late 1985.

- Recommended starting conditions are:
  - Random Vibration:
    - Spectral density: 6g rms
    - Frequency limits: 100-1000Hz
    - Axis: 3
    - Duration: 10 min.
  - Temperature Cycling:
    - **Rate: 10"C/minute**
    - Range: – 40"C to 60°C
    - Number of cycles: 15 (last must be failure free)
    - Power: On (except cool down)

- **For greatest return on investment, vigorous corrective** actions are made to' adjust manufacturing process to minimize recurrence of defects.

- The ESS program is a **dynamic one.** Procedures are adjusted, as indicated by screening results, to maximize finding defects efficiently.

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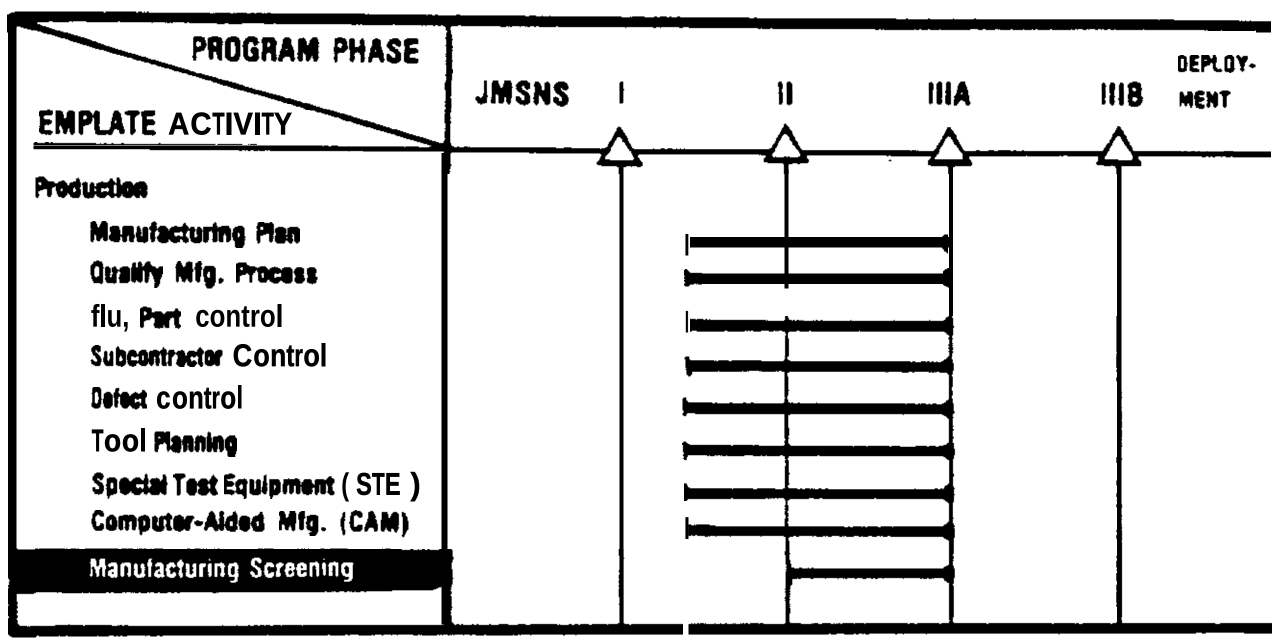
'Sponsored by the Institute of Environmental Sciences (IES), September 19S4.

- Objective of ESS is not to find design defects, although such may be a by-product.

- Appropriate screening for manufacturing defects, as an acceptance test, is developed for other than electrical and electronic products.

TIMELINE




ESS techniques precipitate assembly and workmanship defects, such as poor soldering or weak wire bonds during the assembly process.

# TRANSITION PLAN

TRANSITION PLAN

# CHAPTER 6

## INTRODUCTION FOR TRANSITION PLAN CRITICAL PATH TEMPLATE

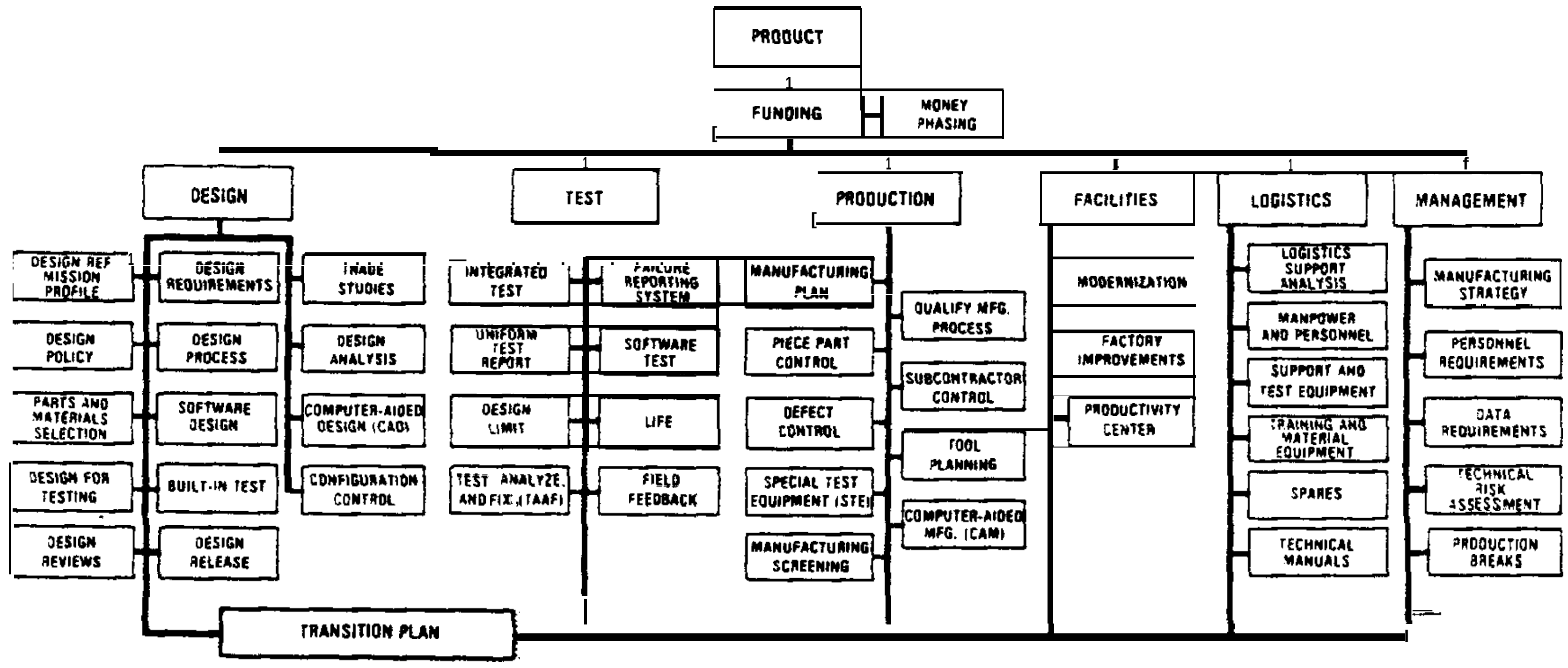
The fundamental purpose of the transition plan is to provide the integration methodology that will tie together the application of templates within the context of the industrial process. To this end, it should be viewed not as a management procedure but as a technical evaluation tool.

This evaluation process begins first by mmprehending fully the technical requirements of the product and, with that understanding, preparing a contractor transition plan (Government-required and-funded) at the start of engineering development. The outlines for reducing risk, contained in the preceding templates, form the basis upon which the transition plan is developed along with the means by which design readiness and maturity, test readiness and maturity, and manufacturing readiness and maturity are assessed continuously for the build-up of risk.

An additional ingredient of the transition plan is provision of the means and explanation of the procedures that clearly delineate the timing of the engineering disciplines, criteria that are to be satisfied while carrying out each discipline, data required to assess the criteria, and the significant risk-driving relationships between the templates contained in this document.

The final objective of the transition plan is to provide visibility on how well the template generated actions for reducing risk are being executed. Therefore, progress reports should be compared regularly against the transition plan.

# TEMPLATE




## TRANSITION PLAN

### AREA OF RISK

In the past, a lack of formal transition planning has contributed significantly to the problems encountered in the transition from development to production. One of the major causes has been a Government/industry attitude that the performance parameters must be achieved during engineering development before expending funds to achieve production objectives. While there were a number of milestone-oriented Government requirements during the development phase and before the. start of production, these were really stand-alone requirements generally used to verify the design's performance goals or as negotiation materials not having a smooth transition as an end objective.

### OUTLINE FOR REDUCING RISK

- Formal Government policies and specified contractual requirements that lay the groundwork for planning, programing, and executing specific actions during the development phase to ensure a smooth and successful transition to production are set forth in DoD Directive 4245.6 (reference (h)) and DoD Directive 4245.7 (reference (i)).
- The Government program manager is required to fund and execute a contractor-developed transition plan, initially prepared no later than the start of engineering development and continually updated until rate production is achieved.

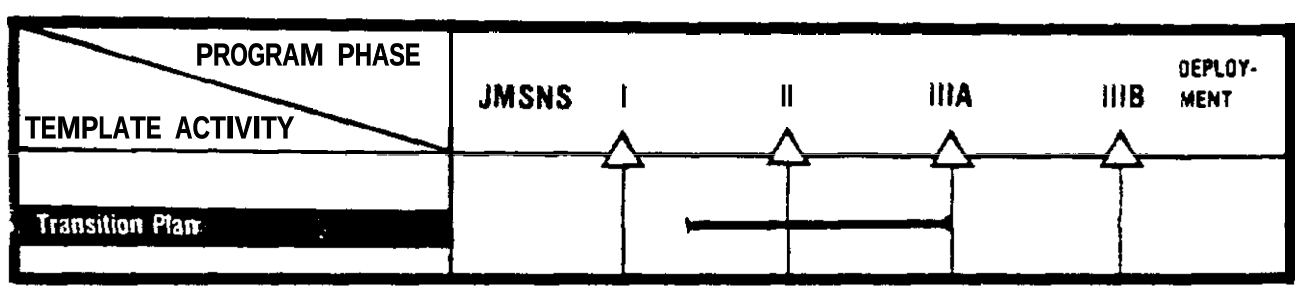
- A sample transition plan outline includes, but is not limited to, consideration of all templates in this Manual. The transition plan integrates the design, test, and manufacturing activities in order to reduce data requirements, duplication of effort, costs, and schedule. It identifies, for example, test and manufacturing issues that impact design, and design issues that affect test and manufacturing. The transition plan is a major means of implementing the manufacturing strategy described in one of the management templates.

- Development contracts contain the requirement for a formal design-to-unit production cost program and provisions for proof of manufacturing methods and processes. Funding is provided to the contractors for these areas of activity.

- The contractor's approach to obtaining both **producibility in the design and an** effective transition from development to production is solicited in the R FP and weighted heavily in source selection.

- Formal production readiness reviews (PRRs) are conducted jointly by the customer and the contractor during the development effort and completed before the production decision. Participants in these reviews are qualified and experienced both in technical aspects of the product and the manufacturing processes proposed to produce it. PRRs, properly staffed and conducted, will result in both Government and contractor benefits. Government policy and procedures on conducting PRRs are contained in DoD Instruction 5000.38 (reference (j)).

TIMELINE




A transition plan, which is a comprehensive management plan describing all production-related activities that must be accomplished during design, test, and low rate initial production, is needed to ensure a smooth transition from development to full rate production. To be effective, the transition plan should be available before the start of FSD and updated regularly so that low rate production can be initiated at minimal risk.

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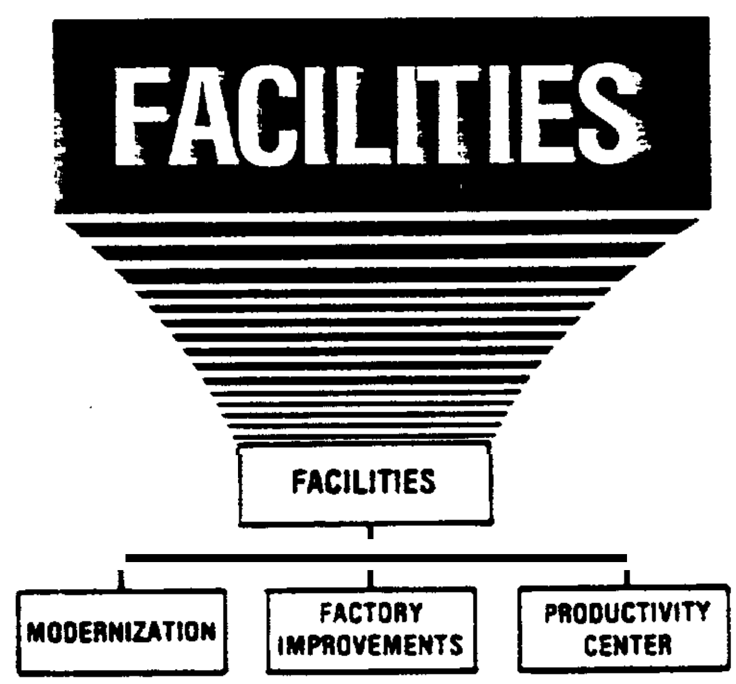
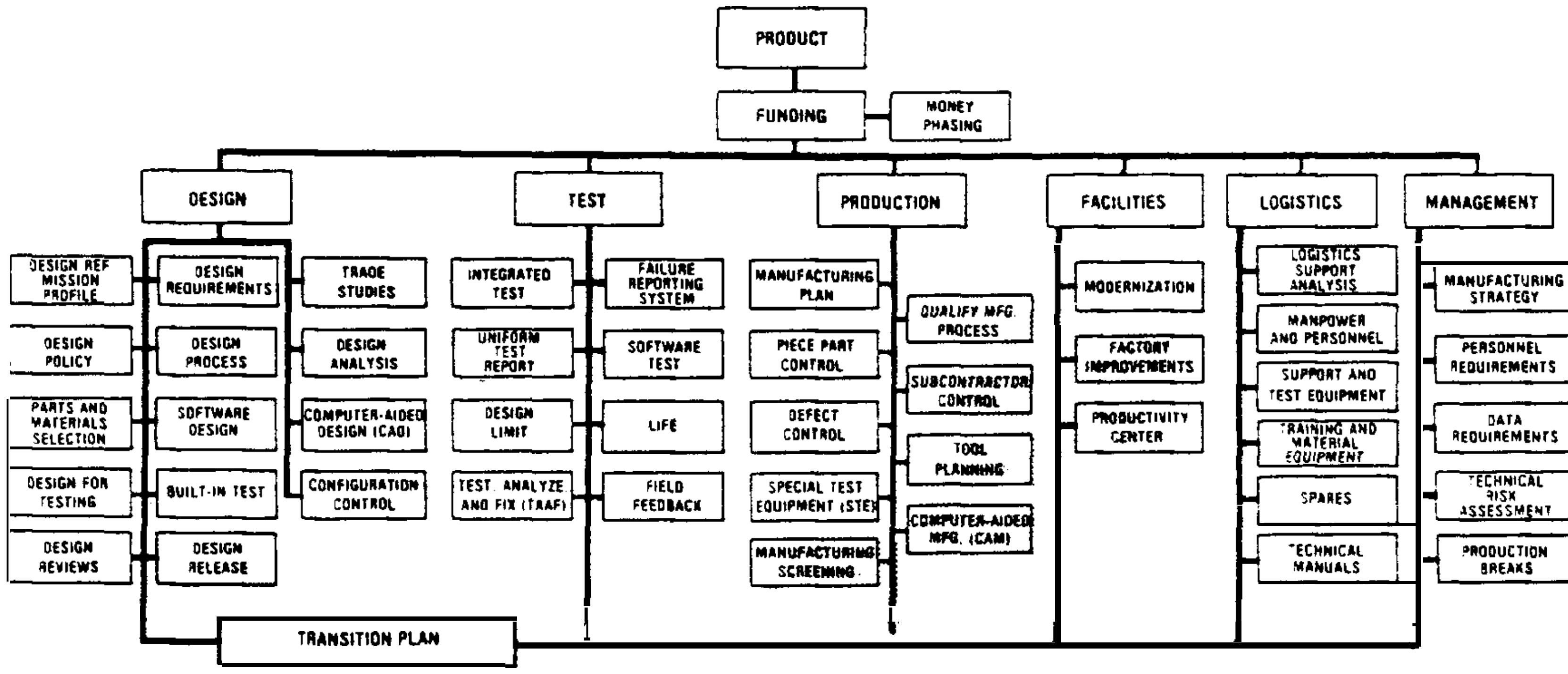

FACILITIES
FACILITIES
MODERNIZATION
FACTORY IMPROVEMENTS
PRODUCTIVITY CENTER

# CHAPTER 7

## INTRODUCTION FOR FACILITIES AND CAPITAL INVESTMENT CRITICAL PATH TEMPLATES

Three templates are provided in this section. The first, Modernization, is based on DoD's new Industrial Modernization Incentive Program (IMIP) that permits profits to increase as modernization activities reduce costs to produce. The second, Factory Improvements, is an outline of an electronics factory that contains the equipment required to implement a low risk manufacturing operation. The third, Productivity Center, is a method for upgrading the skills of personnel using the new equipment and processes on the factory floor.

# TEMPLATE




## MODERNIZATION

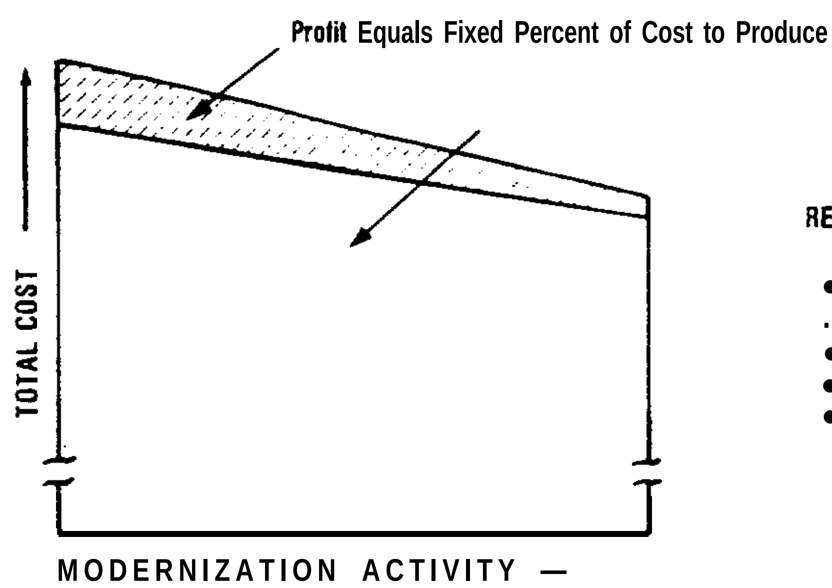
AREA OF RISK

Current approaches to Government contracting fundamentally inhibit industry investments to modernize. Why? Profits are a fixed percent of the cost to produce. See figure 7-1. The rate of modernization is low because profits go down as costs to produce go down. The capital to invest in modernization activities is not available in Government business. Why modernize? Increased productivity reduces costs to produce. The defense industrial base surge capability is improved. U.S. industry's position in the international marketplace has improved. The increased market improves the U.S. balance of payments and produces more jobs. Automation improves quality. The talent, material, and computer software required to implement the design and manufacturing fundamentals for reliable products are made possible by increased capital, and reduce the risk of transitioning from development into production.

**OUTLINE** FOR REDUCING RISK

- The DoD **IMIP** permits profits to increase as costs to produce decrease. This provides additional capital that is available to increase the rate of modernization that increases productivity and further reduces production costs, and thus overall costs to acquire defense material. See figure 7-2. The objective is to increase the rate of modernization.
- Sing/e product incentives are considered, when appropriate. These incentives result in contractor proposals for major productivity enhancements, limited overall factory modernization, and large unit cost savings. Unit cost savings examples (using 1982 dollars) are as follows:

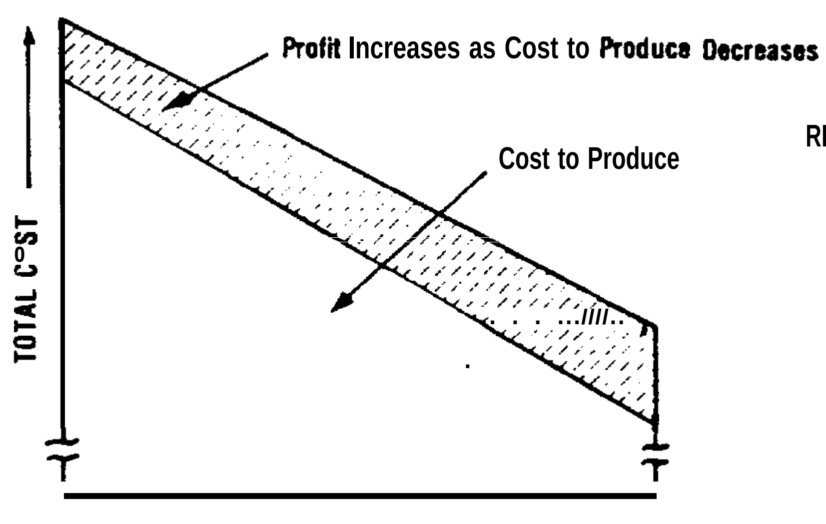
| ITEM | INVESTMENT | SAVINGS TO DATE | EST. TOTAL SAVINGS |
|---|---|---|---|
| Cross Field Amplifier | $256,000 | | $22,300,000 |
| Radome | 116,000 | $350,000 (1982) | 4,000,000 |
| Torpedo Propeller | 286,000 | | 15,500,000 |




RESULT:

- No Incentive to Modernize
- Higher Costs
- Lower Productivity
- Lower Quality
- Less Capable Industrial Base

Figure 7-1. The Old Approach




RESULT:

Incentives to Modernize

- Lower Costs
- increases Productivity
- Increases Quality
- Improves Industrial Base
- Improves International Competitive Position
- Improves Markat, More Jobs
- Increases Profits

Figure 7-2. The New Approach (IMIP)

- Mu/tip/e ***product*** incentives are considered, when appropriate. These incentives result in contractor proposals for major product-oriented productivity enhancements and factory modernization improvements. An example of results:

  – Savings: initial investment = $70,000,000
    estimated savings = 430,000,000

  – Modernization improvements: automated material handling, automated assembly of cables and harnesses, and automated printed wiring assembly station.

- *The multiple* product, ***single DoD focal point concept*** is utilized. When a factory deals with a single DoD focal point as the customer for all its products and profits increase as costs to produce decrease, modernization of the DoD industrial base may take care of itself.

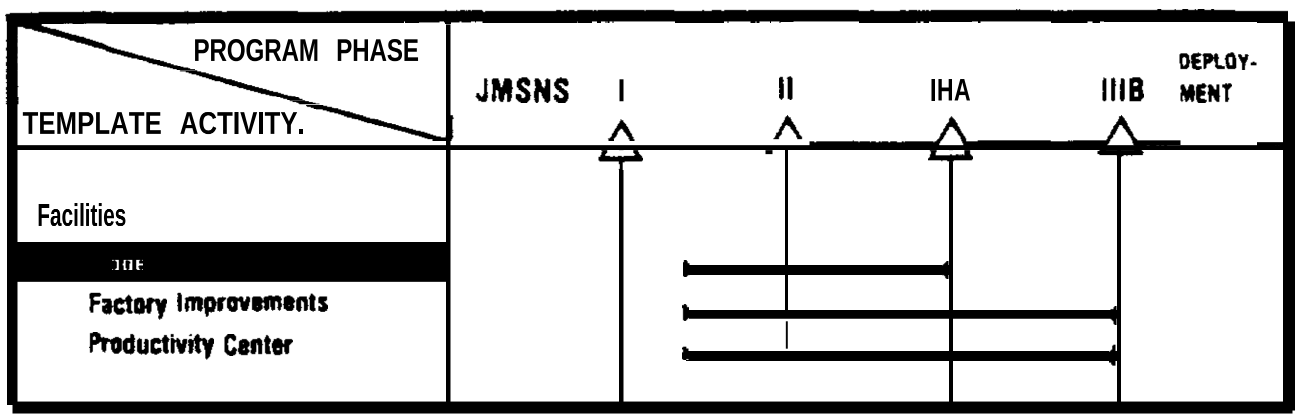
- Modernization activities are checked carefully against their impact on life cycle cost, i.e., product *quality.*

- Contractor *funding* of modernization activities is preferred by the Government, and resultant savings are shared by the contractor and the Government. The contractor's investments are guaranteed by the Government, when appropriate.

- Modernization activities are ***f/owed down*** to subcontractors and suppliers, to accrue the greatest benefits.

- All defense materials, not ***just*** weapon systems, are considered candidates for modernization activities.

## TIMELINE




Factory modernization is essential to cost-effective production of today's sophisticated weapon systems. Modernization activities primarily are oriented to support ail of the factory's product lines. However, there may be program-related activities. In these cases, detailed planning is done early enough to influence the design, as appropriate and required.

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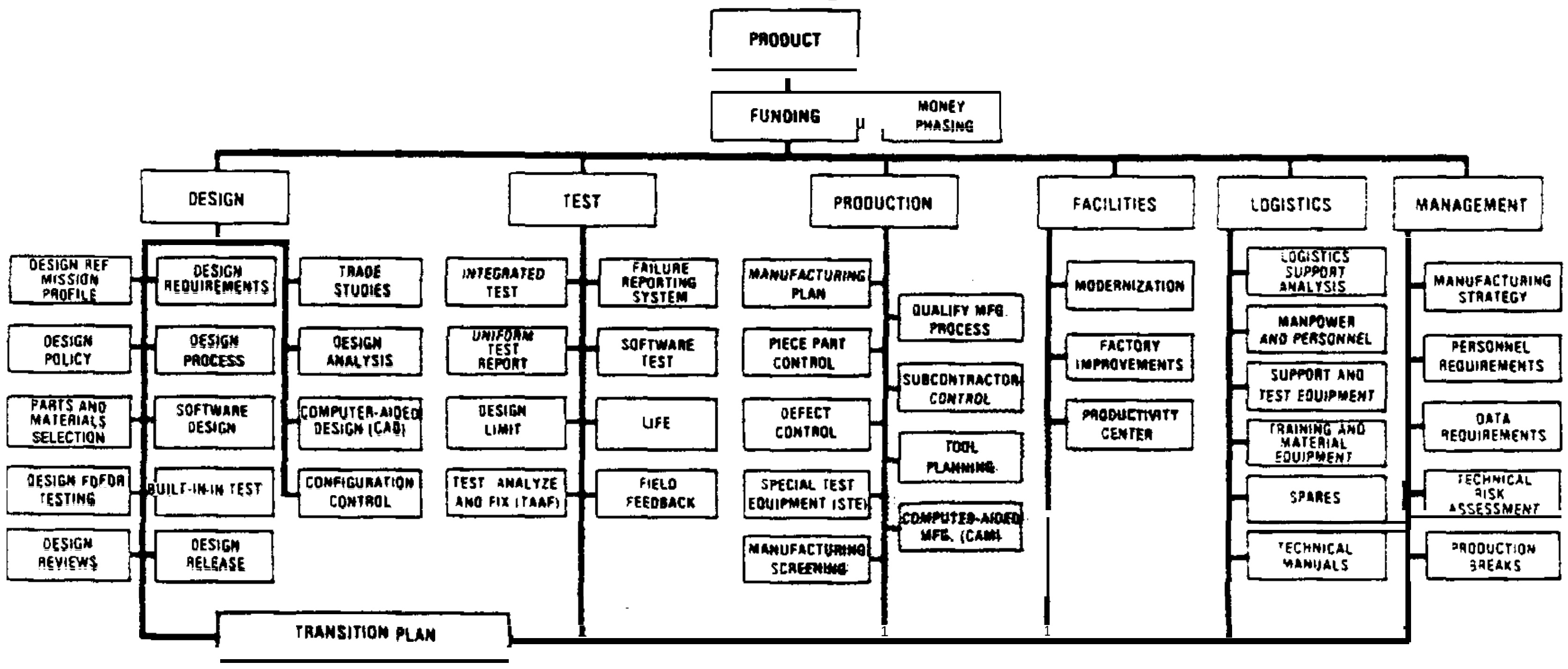
# TEMPLATE




## FACTORY IMPROVEMENTS

AREA OF RISK

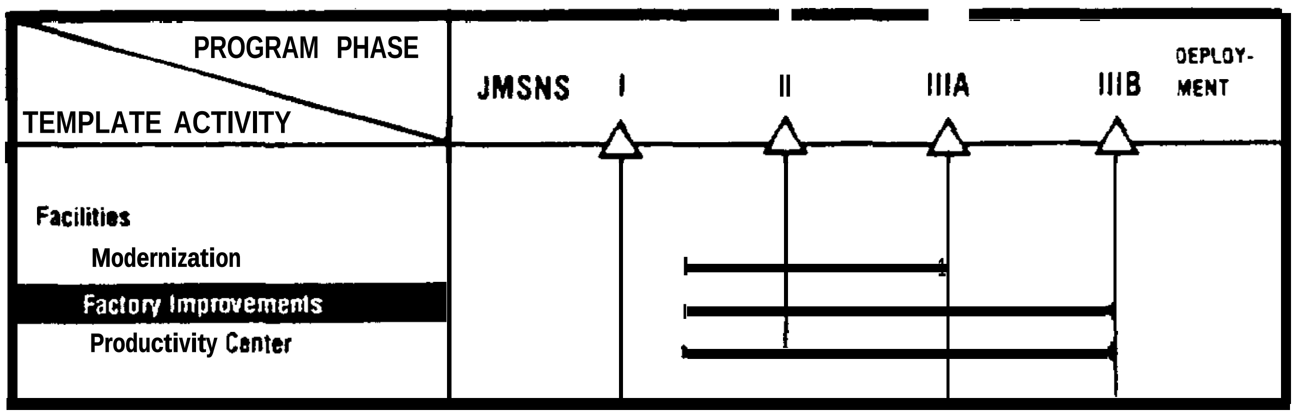
Many equipment failures in the field can be attributed to excessive manual assembly and test operations in the manufacture of assemblies. In-plant failures from manual errors in assembly and test contribute to excessive rework and repair costs (i.e., "the hidden factory"). These risk areas increase production and life cycle costs and result in major schedule risks. These risks are acute particularly during the transition from development to production. The use of semiautomatic equipment in electronics manufacturing is essential in reducing these risks. This template illustrates an optimum facility for electronics assembly and test using available "off-the-shelf" electronics manufacturing equipment.

OUTLINE FOR REDUCING RISK

- Incoming inspection and automatic kit preparation ensure that high quality and correct components are used on the assembly line.
  - Typically, an 80 percent reduction in component defects can be achieved.
  - Exhibit 7-1. generically illustrates an example of incoming inspection and kit preparation areas.
- Semiautomatic and fully automated circuit board assembly techniques increase productivity and minimize assembly and workmanship defects.
  - Typically, a 2:1 reduction in defect rates can be achieved.
  - Exhibit 7-2. generically illustrates an example of a circuit board assembly and test area.

- Semiautomatic assembly and test techniques maximize productivity and minimize workmanship defects on electronic assemblies.
  - Typically, a 3:1 improvement in productivity can be achieved.
  - Exhibit 7-3. generically illustrates an example of an electronics subassembly and test area.
- One hundred percent piece part inspection of electronic parts reduces risk, is cost-effective, and should be a routine operation in incoming inspection.
- A productivity center for personnel training and development of any equipment integration minimizes the risk of unforeseen throughput problems.
- Computer-assisted functions include a data interface between the design and operations management functions.
- Each assembly, test, and inspection station should have computer-aided data entry capability.

TIMELINE




The use of state-of-the-art factory equipment can prevent many common workmanship errors. The type of facility planned for the manufacture of the end item product should be identified during engineering development, and should be evaluated periodically from development until full rate production is achieved.

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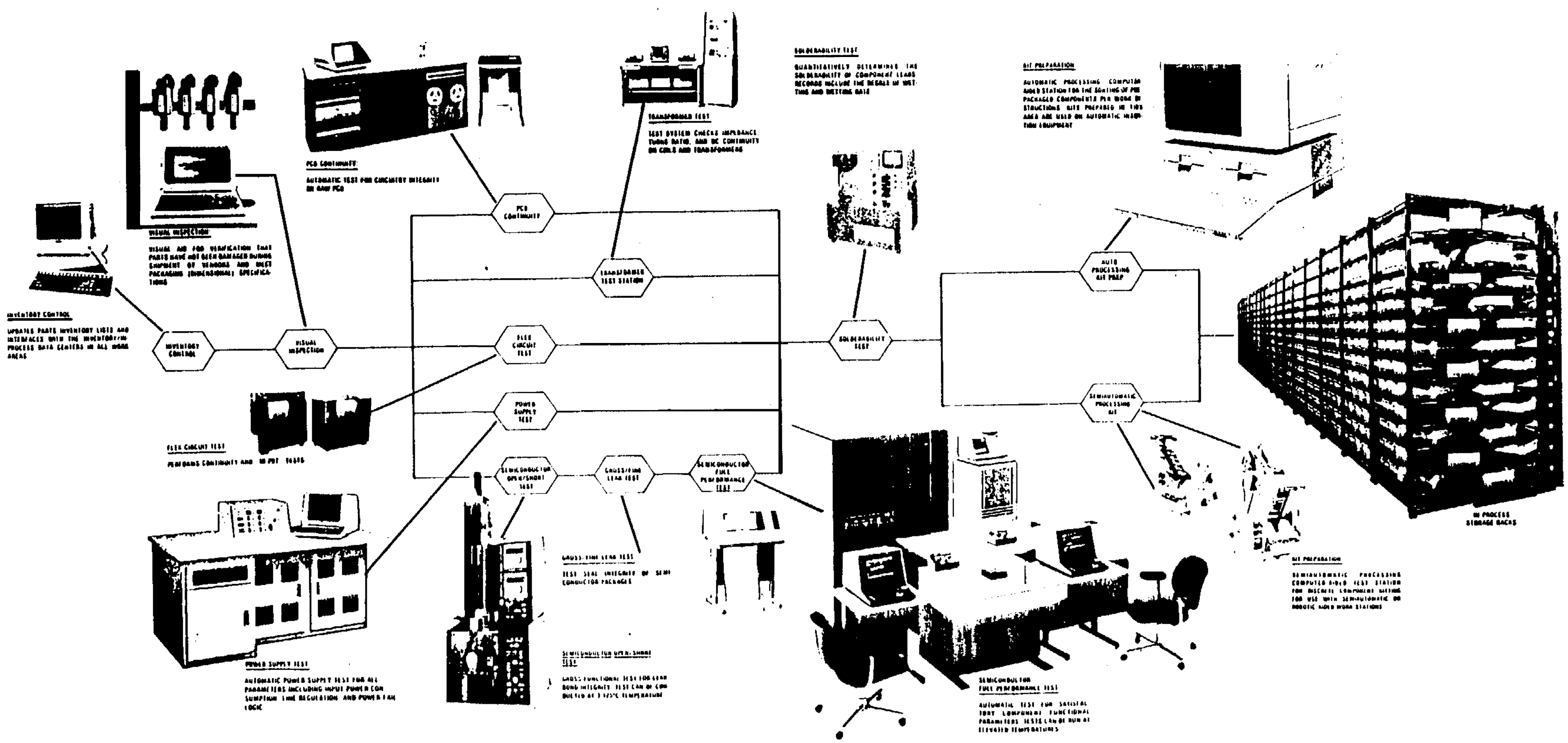


EXHIBIT 7-1. INCOMING INSPECTION AND KITTING

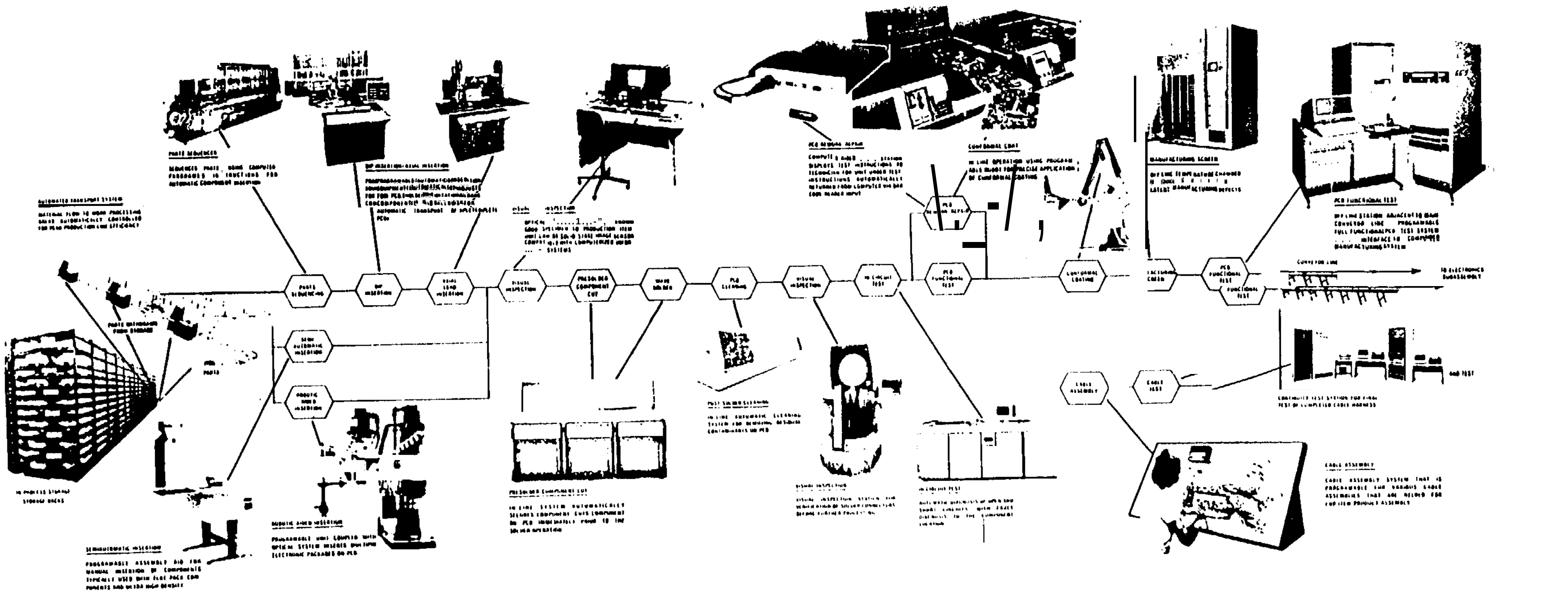

EXHIBIT 7-2. PRINTED CIRCUIT BOARD ASSEMBLY AND TEST

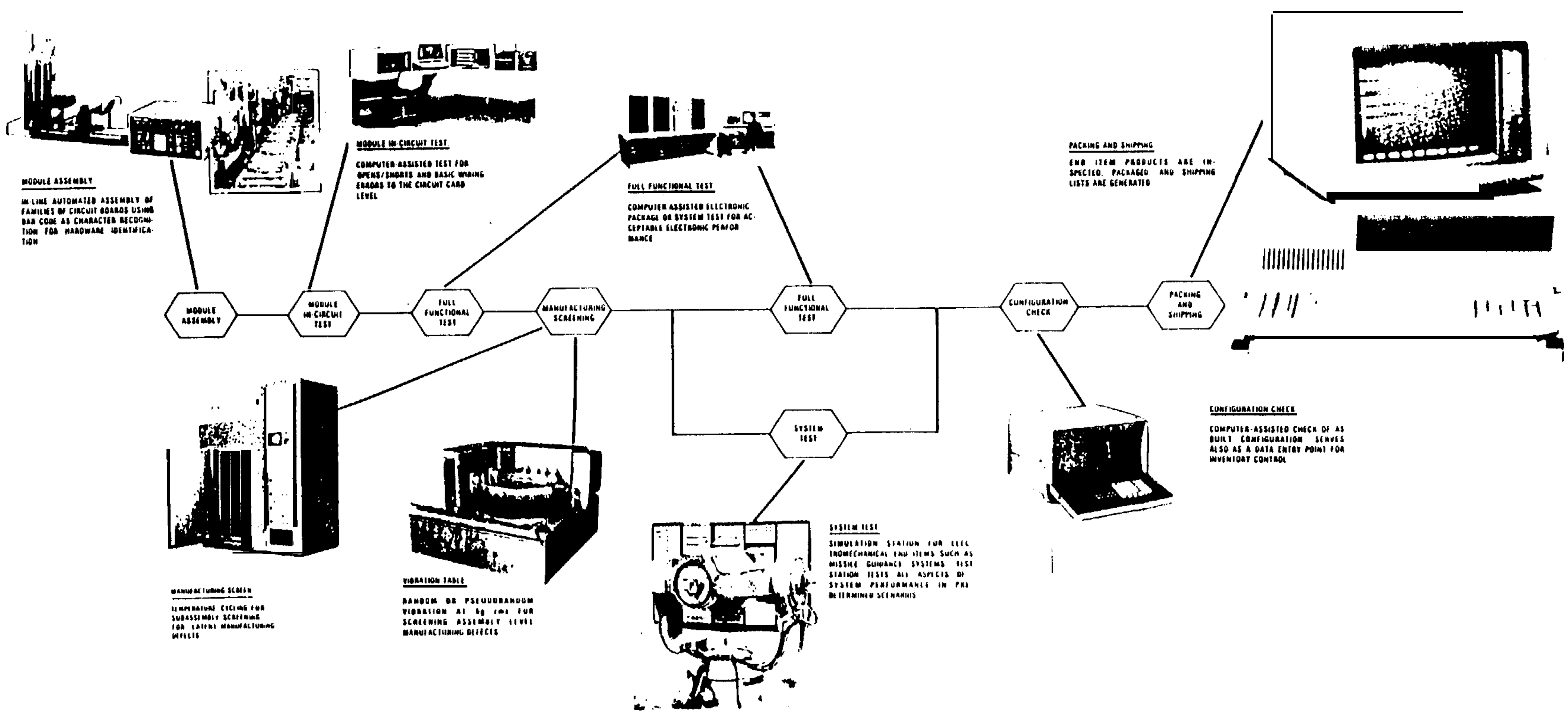


EXHIBIT 7-3. ELECTRONICS ASSEMBLY AND TEST

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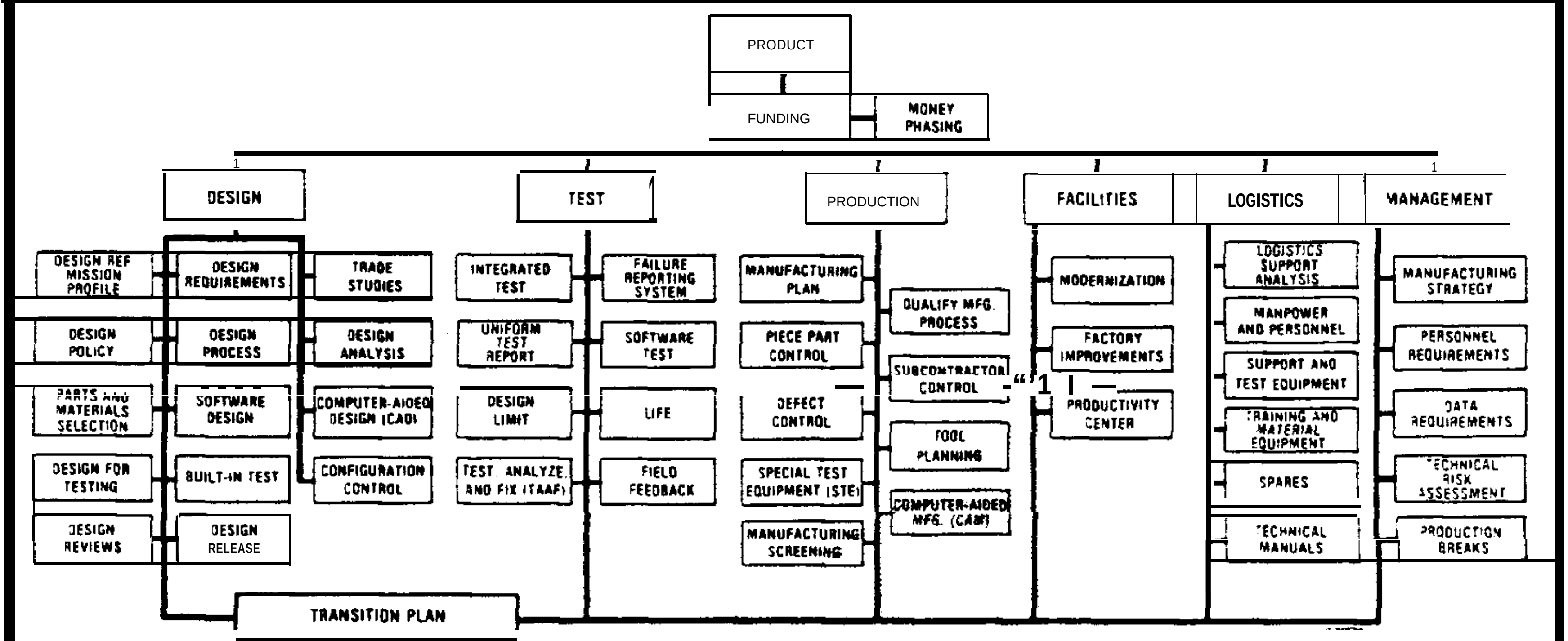



## PRODUCTIVITY CENTER

AREA OF RISK

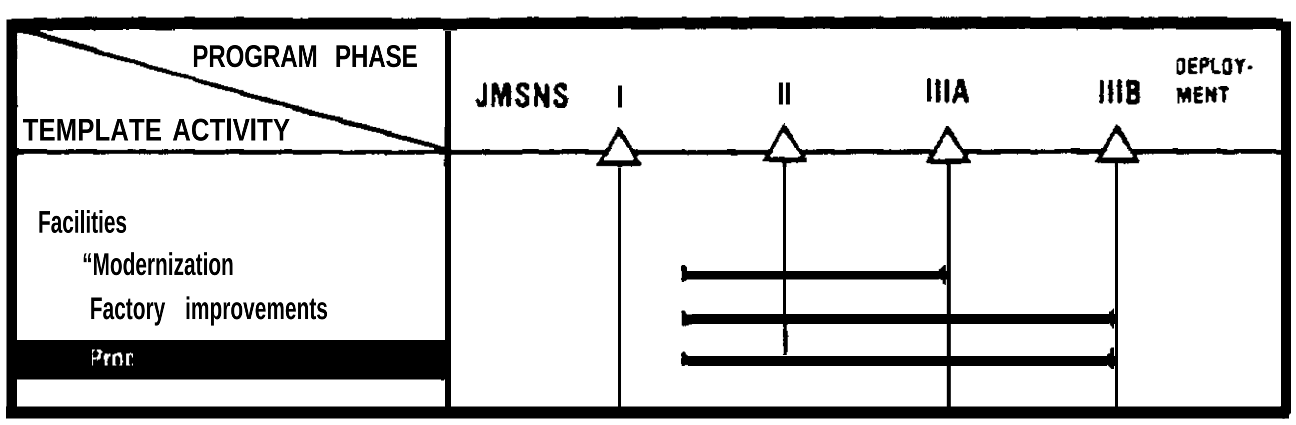
The use of changing technology on the factory floor without qualified personnel can be counterproductive, lowering or eliminating the productivity gains anticipated from the capital investment in modernization and factory improvement. Thus, maintaining a stable labor force as new technology is introduced on the factory floor is a risk area. This risk area is amplified with the introduction of new “state-of-the-art” products that are typical of today’s military weapon systems. Training and maintaining the skill of the labor force, therefore, presents a significant risk in the transition to production. A productivity center that updates the skills of the work force and provides orientation training for new product lines is a catalyst for maintaining a well-trained labor force. This template provides a framework for an effective productivity center.

OUTLINE FOR REDUCING RISK

- productivity center includes an apparatus lab that contains the equipment and technologies that represent the actual facility producing a product.
  - Use of the apparatus lab includes simulation of production equipment hardware and end item defects.
  - The apparatus lab evaluates new processes or process changes before introduction at the main facility. This technique ensures that any change to existing procedures will not affect adversely normal production flow.
- productivity center includes a learning center for classroom instruction for updating the skills of manufacturing personnel.

- Training system is flexible and individual performance oriented.
  - – Sixty percent is “hands on” training in apparatus lab.
  - – Forty percent is formal classroom instruction.
  - – Attention is given to skill assessment and the motivation aspects of worker retraining.
- Typical training courses include the following:
  - – Product orientation.
  - – Manufacturing facility orientation.
  - – Electronics manufacturing and test operations and procedures.
  - – Numerical control machine operations.
  - – CAM.
  - – Diagnostics for troubleshooting and repair (system level).
  - – Microprocessor troubleshooting techniques.
  - – Computer technology.

TIMELINE




A productivity center provides an “off-line” capability to evaluate manufacturing techniques for worker retraining for production line improvements. As new technology, equipment, manufacturing processes, or test procedures are identified for the efficient production of a specific product, personnel must be trained to perform these new tasks. Manufacturing engineering concurrent with design engineering will identify these tasks during development, and additional tasks will be identified until rate production has been achieved.

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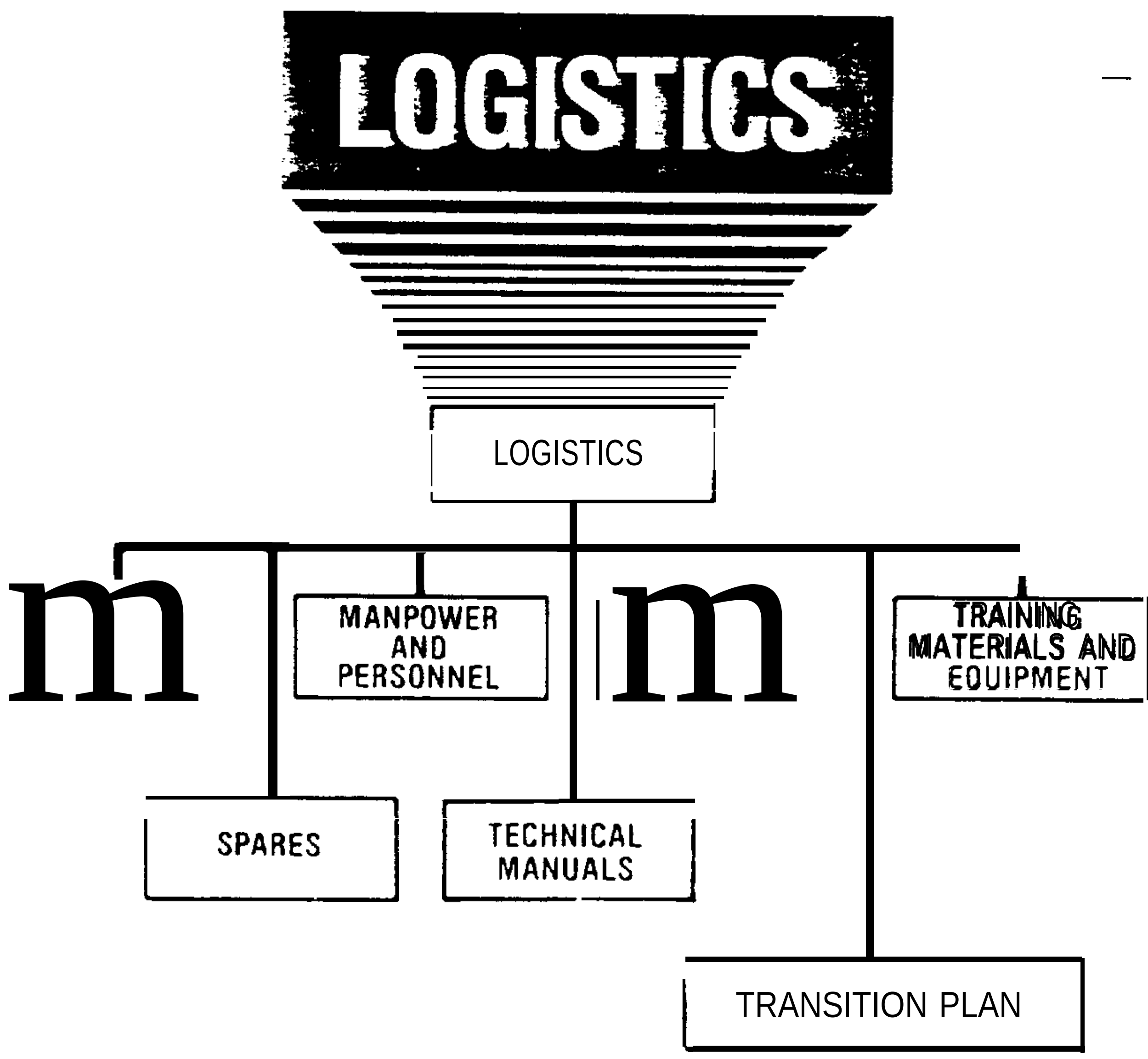

LOGISTICS
LOGISTICS
MANPOWER AND PERSONNEL
TRAINING MATERIALS AND EQUIPMENT
SPARES
TECHNICAL MANUALS
TRANSITION PLAN

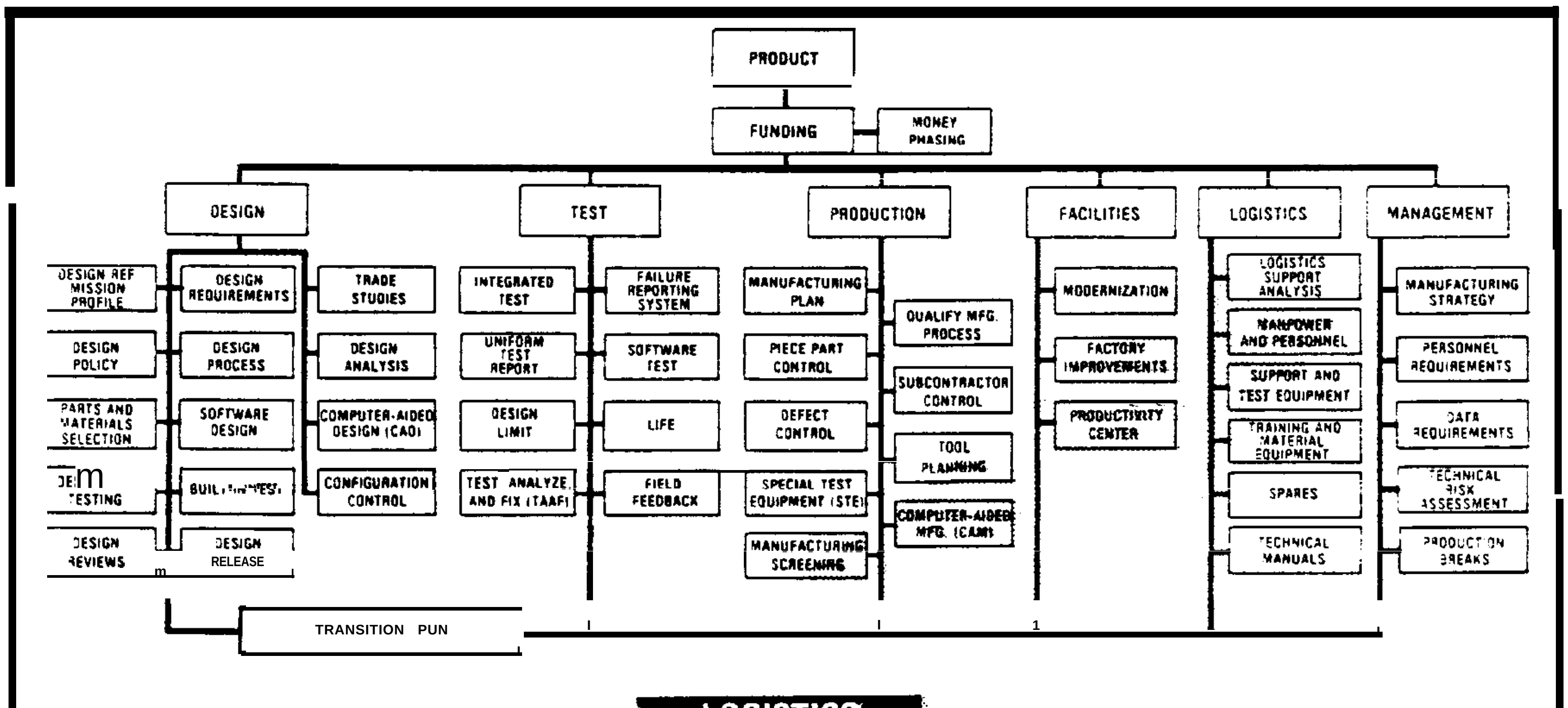
# CHAPTER 8

## INTRODUCTION FOR LOGISTICS CRITICAL PATH TEMPLATES

The primary purpose of the acquisition process is to field weapon systems and equipment that not only perform their intended functions, but are ready to perform these functions when called on, and to do so over and over again without unplanned maintenance and logistics efforts. However, numerous examples abound when new systems, when fielded, do not achieve readiness levels to meet service needs, necessitating engineering and manufacturing changes as well as additional equipment, spares, and maintenance resources, all of which increase cost as well as production and deployment risk.

The templates in this section address logistics and supportability issues that contribute to the risk of transition from development to production. Accordingly, they do not explicitly refer to all integrated logistics support (ILS) elements or outline a total strategy for I LS planning and management in the acquisition process. These elements and strategy are covered in DoD Directive 5000.39 (reference (k)) and Military Service implementing documents. As specified in reference (k), the acquisition manager is required to develop an ILS plan that successfully coordinates the areas addressed in this logistics section. The logistics elements and supportability issues and their requirements, outlined in this section, represent those that have been particularly difficult and destabilizing, and require special attention. Therefore, the implementation of the concepts, procedures, and techniques discussed in this section will reduce significantly the risk of transition from development to production and deployment.

# TEMPLATE




## LOGISTICS SUPPORT ANALYSIS

AREA OF RISK

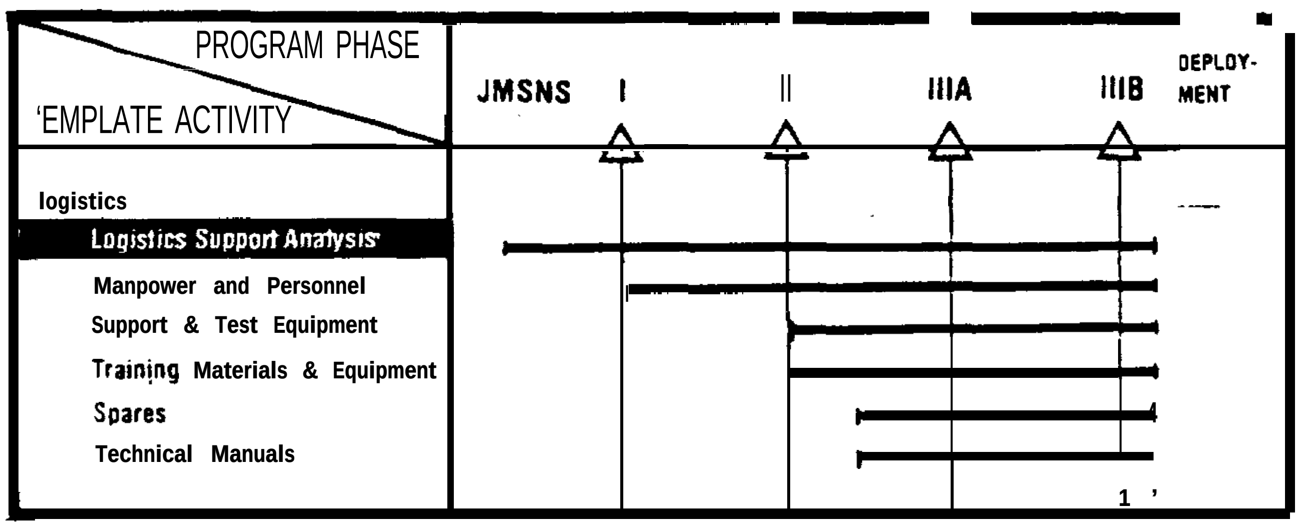
Logistics Support Analysis (LSA) is used throughout the acquisition process to evaluate design approaches and alternative support concepts to achieve system readiness and support objectives, and to develop detailed design of the support system and requirements. Weapon system programs that have either delayed the application of LSA or have not integrated it effectively into the design analysis process are headed for trouble. The result is supportability deficiencies that increase costs and require additional engineering changes to correct these deficiencies late in the development and production process.

OUTLINE FOR REDUCING RISK

- Design objectives and development of design options to achieve readiness and supportability objectives are required by the engineering statement of work (SOW).
- LSA is integrated into the design process to determine design impact on support.
- The LSA process has identified high leverage subsystem and component reliability and maintainability efforts needed to achieve readiness and deployment objectives.
- Quantitative logistics and supportability requirements are given explicit weight in source selection.
- LSA data is derived from the same source data used by design and test engineering.
- The engineering disciplines have an “agreed to” methodology for quantifying readiness and supportability design impacts.

- Disposition of LSA-identified cost and performance drivers are coordinated with the users to permit meaningful tradeoffs.
- Adequate funding and technical manpower are programed to perform LSA analyses required during the concept demonstration and validation phase and followup.

## TIMELINE




The LSA is begun early in the development process to explicitly address supportability and support requirements throughout the design, development, and production process.

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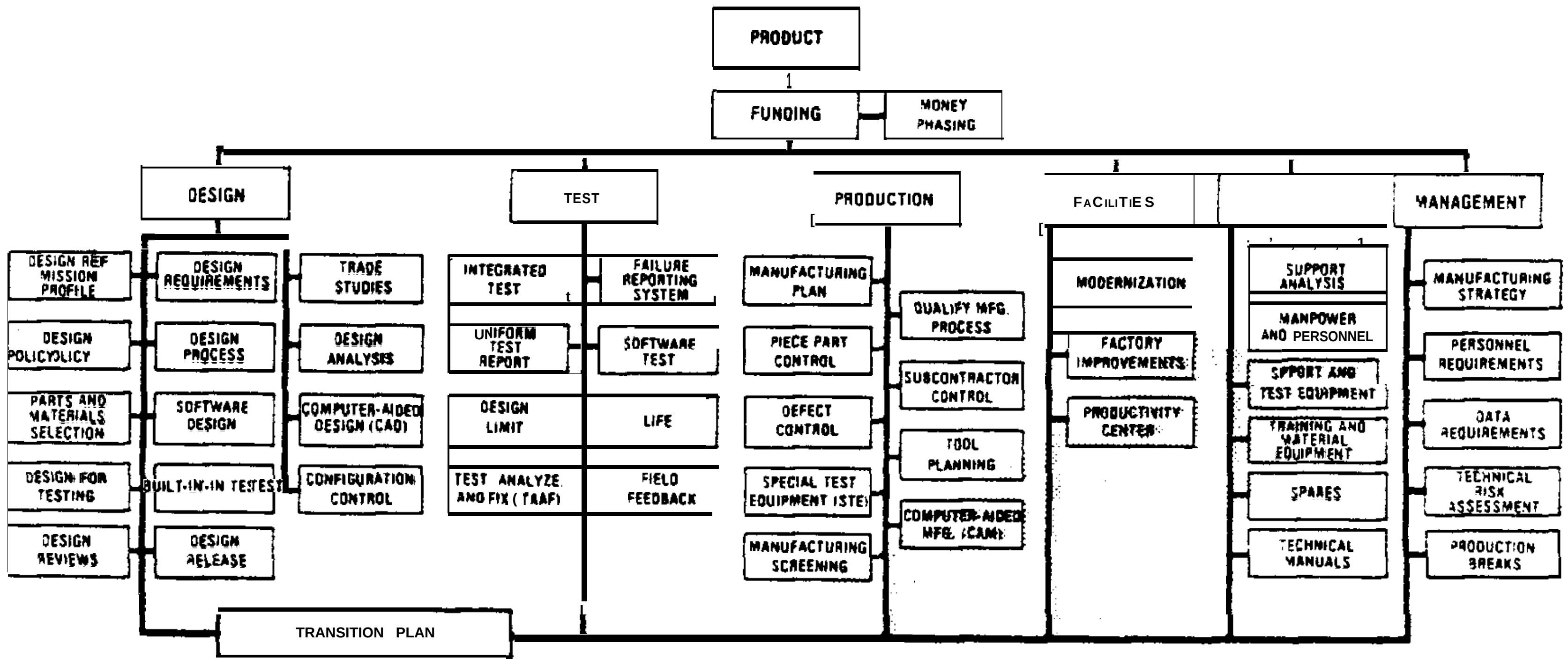



## MANPOWER AND PERSONNEL

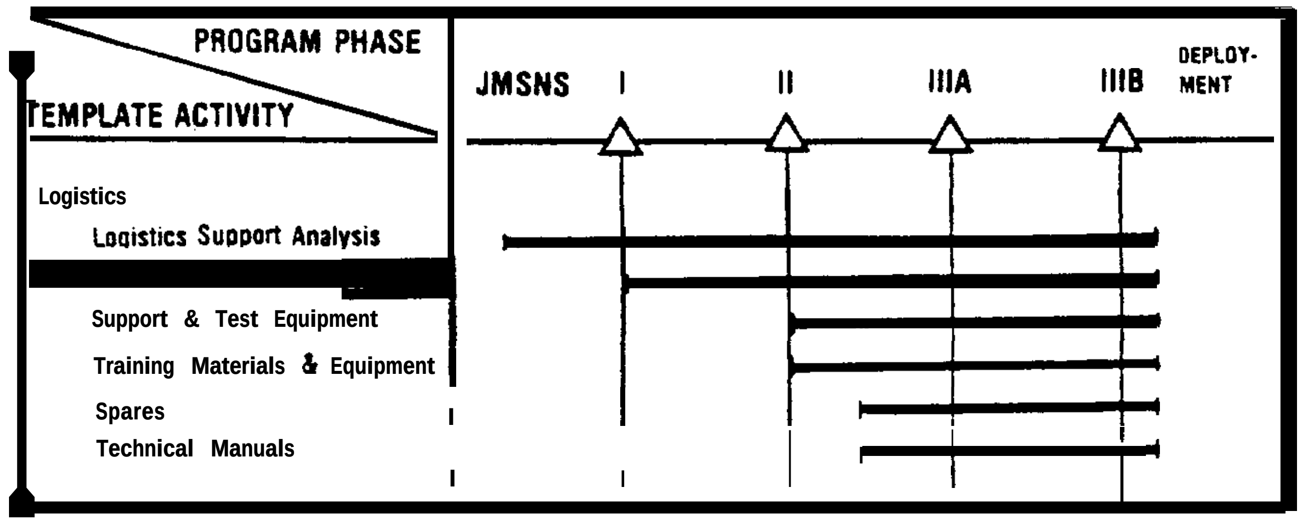
AREA OF RISK

Weapon systems and support systems must be designed with as complete an understanding as possible of user manpower and personnel skill profiles. A mismatch yields reduced field reliability, increased equipment training, technical manual costs, and redesign as problems in these areas are discovered during demonstration tests and early fielding. Discovery of increased skill and training requirements late in the acquisition process creates a difficult catchup problem and often leads to poor system performance.

OUTLINE FOR REDUCING RISK

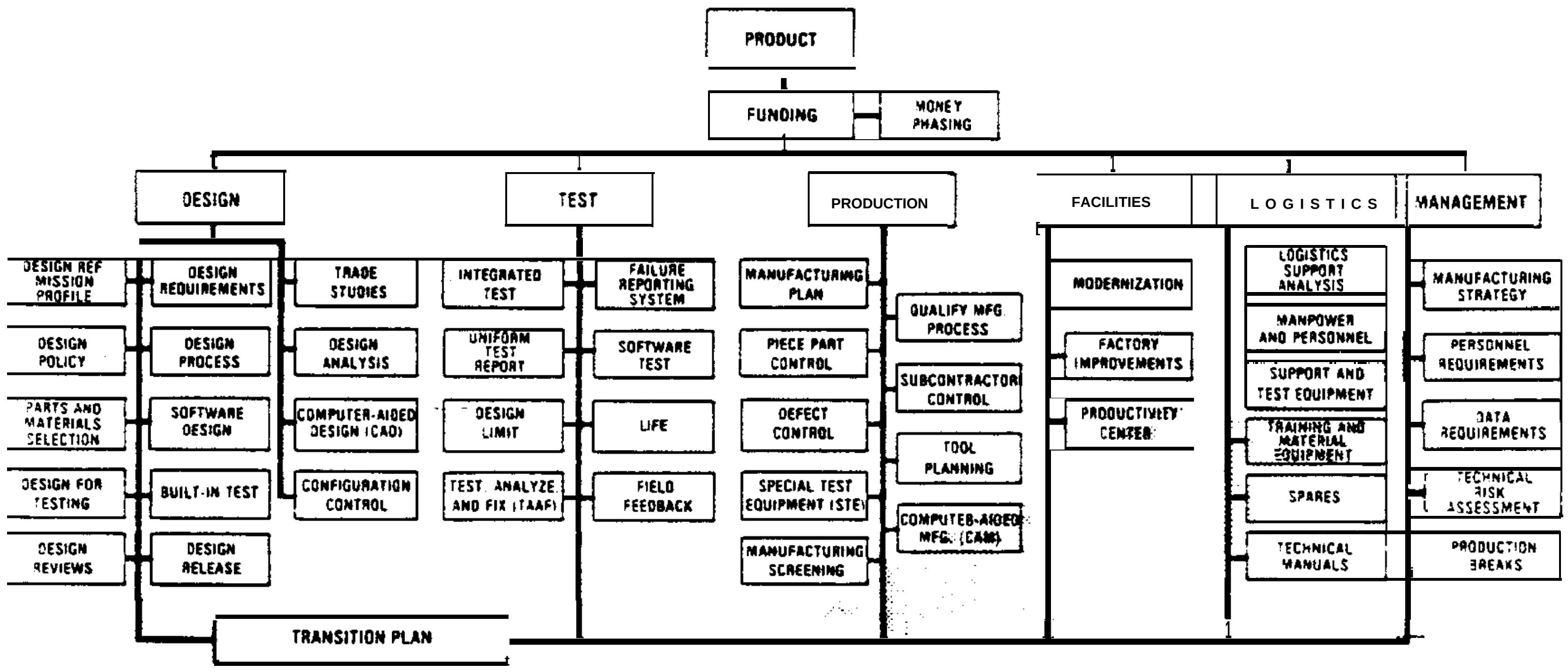
- Manpower and skill requirements are based on formal analysis of previous experience on comparable systems and maintenance concepts. This is done under contract during the preconceptual through validation phase.
- RFPs reflect the required priority for reducing manpower quantities or skill requirements. This is backed up by detailed descriptions of current and projected manpower skill resources and shortfalls. This data includes specific information on current maintenance and operator performance and realistic manpower costs on similar fielded systems.
- Arrangements are made for the contractor to observe maintenance in the field to gain appreciation for capabilities and constraints.
- Manpower cost factors used in design and support tradeoff analyses take into account costs to train or replace experienced personnel, as well as billet and true overhead costs.

TIMELINE




Manpower and skill requirements are established early in the conceptual phase and are considered as prime design considerations during development. They are addressed specifically during LSA, and tradeoffs in design are made to minimize their requirements.

# TEMPLATE




**SUPPORT AND TEST EQUIPMENT**

AREA OF RISK

Weapon system supportability is dependent on reliable and maintainable support and test equipment that can be deployed with the prime system. However, the development, production, and fielding of this equipment have been a common source of risks in terms of increased costs, schedule delays, and poor performance and readiness for fielded systems. The more significant causes of this risk are: (1) delayed identification of support equipment requirements; (2) design and development of software intensive support equipment before design stability of the system it supports; (3) underestimation of software requirements and development costs; and (4) failure to apply sound engineering, manufacturing, and management disciplines to the design, development, test, and production of support and test equipment.

OUTLINE FOR REDUCING RISK

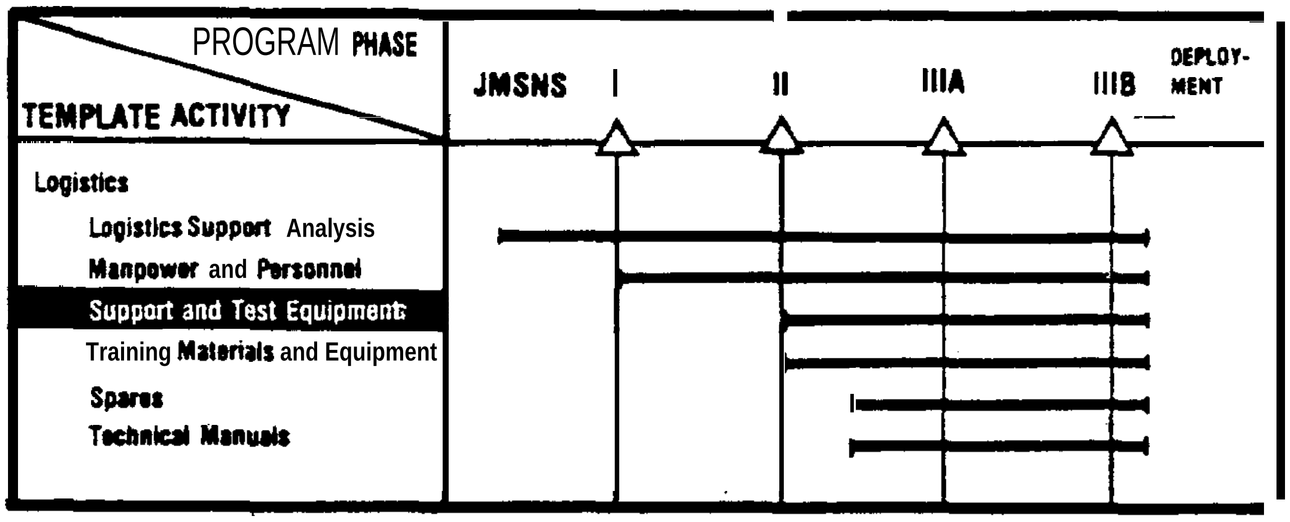
- Identification of support equipment needs, as part of the LSA process, is initiated as early in development as prime system concept permits.
- Test equipment performance specifications include criteria for fault detection, isolation, and false indications.
- Phased contractor support is utilized to allow for design instability.
- Test equipment performance, procedures, and software verification and validation are completed before contractor support termination.
- Upward compatibility is specified between BIT and intermediate, depot, and factory -levels of support equipment.

- Support and calibration requirements for test equipment are included in development and production contracts.

- Estimated costs of test program set (TPS) development are based on comparable equipment development and are funded fully.

- Support and test equipment is evaluated during formal contractor maintainability demonstrations and “in” operational tests.

TIMELINE




Support and test equipment design, test, production, and supportability follow the same processes outlined in this Manual for the prime equipment.

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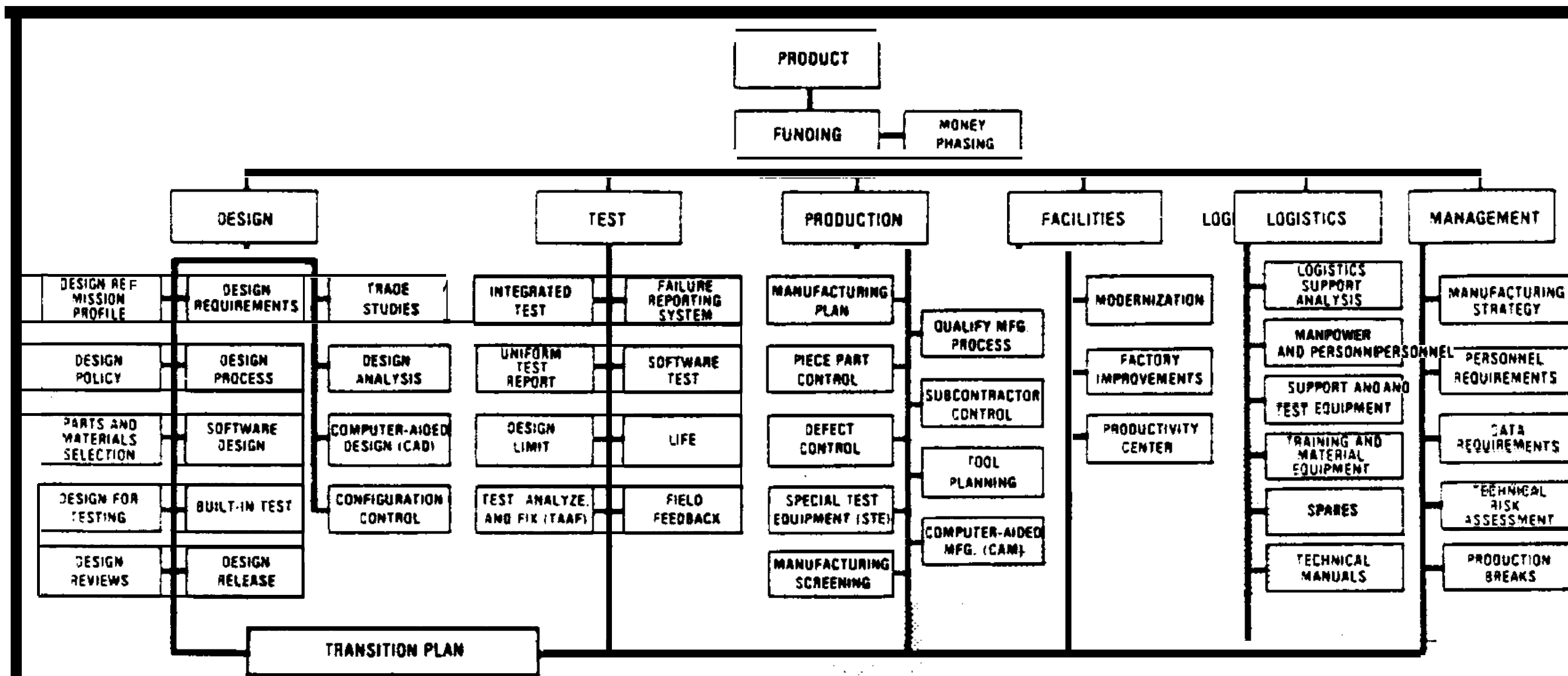



**TRAINING MATERIALS AND EQUIPMENT**

AREA OF RISK

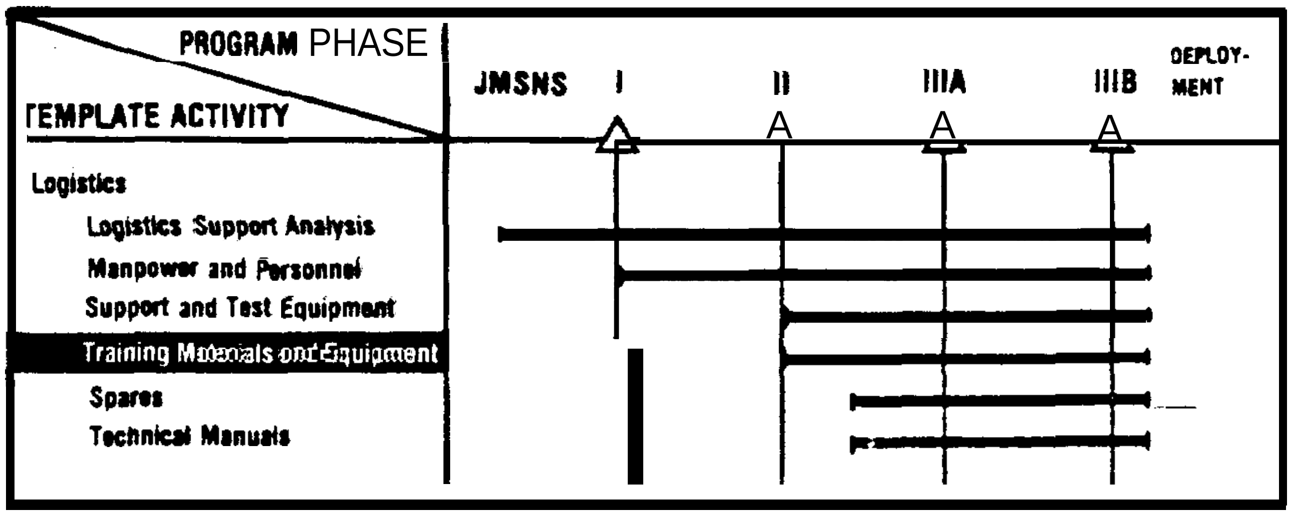
On some programs, training requirements are not addressed adequately, resulting in great difficulty in operation and support of the hardware. Training programs, materials, and equipment such as simulators may be more complex and costly than the hardware they support. Delivery of effective training materials and equipment depends on the understanding of final production design configuration, maintenance concepts, and skill levels of personnel to be trained. On many programs, training materials and equipment delivery schedules are overly ambitious. The results include poor training, inaccuracies in technical content of materials, and costly redesign and modification of training equipment.

OUTLINE FOR REDUCING RISK

- Contractors are provided with clear descriptions of user personnel qualifications and current training programs of comparable systems, to be used in prime hardware and training systems design and development.
- Maintenance tasks identified through LSA provide the data base used in comprehensive training program development systems (such as instructional systems development (ISD)).
- Computer-aided techniques are used for configuration control to ensure consistency between training materials and equipment and the systems they support.
- On-the-job training capability is incorporated in the prime equipment design as a method to reduce the need for additional training equipment.

- Complex and costly training equipment, such as simulators, is scheduled to be produced after design freeze of the prime equipment.

TIMELINE




Training materials and equipment must match maintenance plans. Equipment built-in training features must be established early in the design phase, and the training device design must reflect stable prime equipment design.

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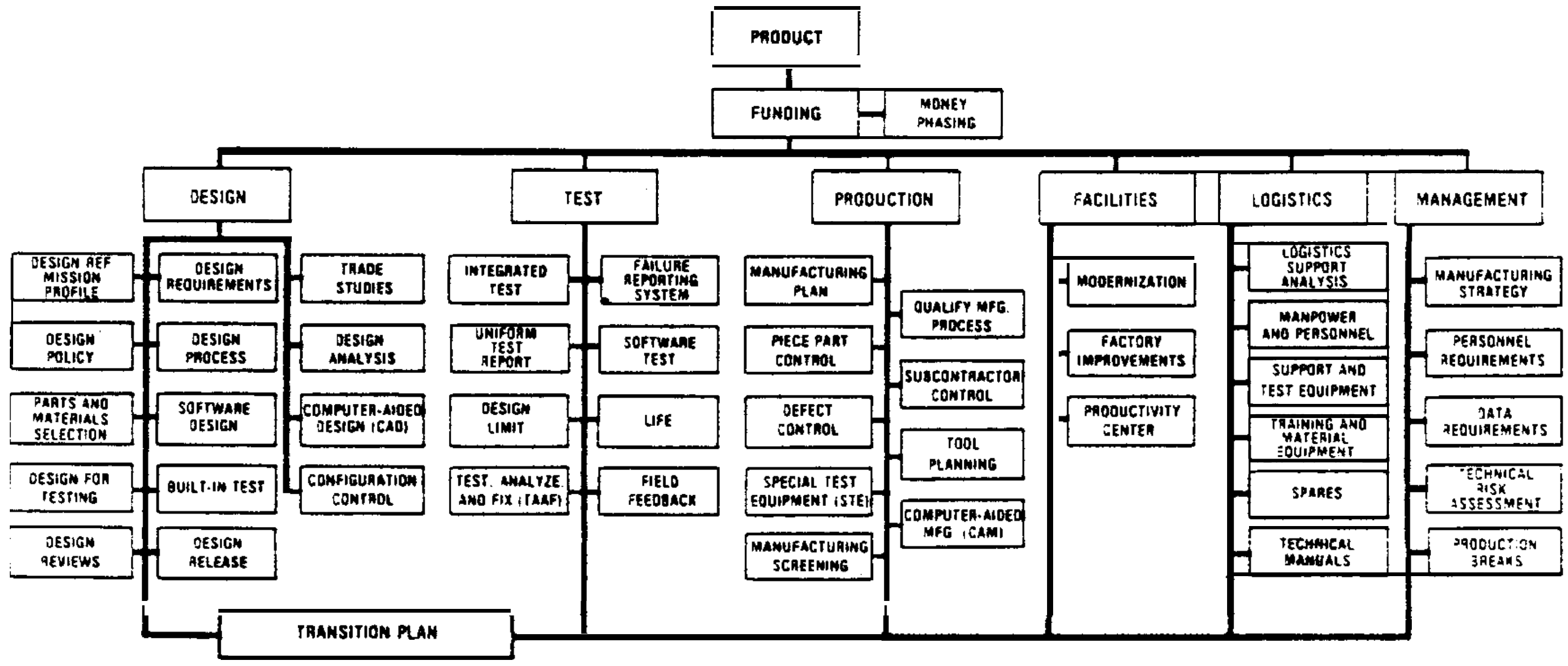



## SPARES

AREA OF RISK

Spares are a troublesome area in the production and deployment of weapon systems. Spares and repair parts often do not meet the same quality and reliability levels as the prime hardware. Full spares provisioning too early in the development cycle, when there are large uncertainties in the predicted failure rates and design stability, results in the procurement of unneeded or unusable spares. inadequate technical and reprocurement data frequently limits competition, acquisition flexibility, and spares manufacturing throughout the iife cycle of the prime systems. Spares thus present a major risk of increased acquisition and support costs and reduced readiness of fielded systems.

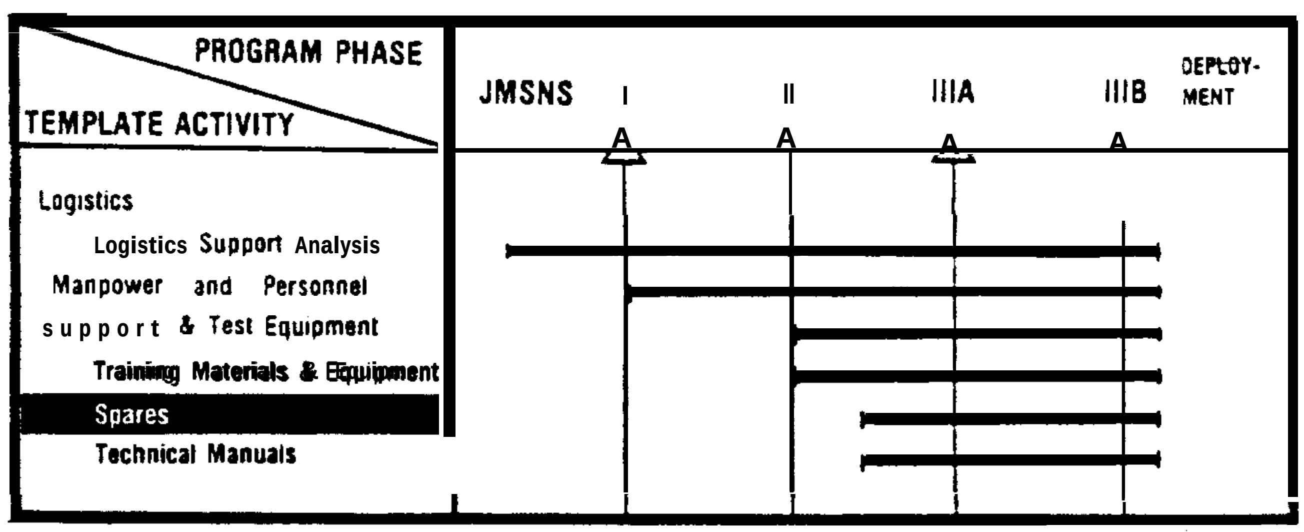
OUTLINE FOR REDUCING RISK

- A spares acquisition strategy is developed early in FSD to identify ieast cost options, including combining spares procurement with production. This strategy addresses spares requirements to meet FSD testing as weii as production and deployment.
- The same quality manufacturing standards and risk reduction techniques used for the prime hardware are used in the spares manufacturing and repair process.
- Transition from contractor to Government spares support is planned on a phased subsystem-by-subsystem basis.
- Initial spares demand factors are based on conservative engineering reliability estimates of failure rates (derived from comparability analysis) and sparing to availability analytical models. These factors are checked for reasonabieness at the system or major subsystem level against laboratory and field test results and documented in the logistics support analysis data base.

. Technical and reprocurement data is validated by analysis and, when possible, by "proof models," to ensure the quality of the spares and repair parts production process.

- **Plans for developing spares procurement and manufacturing options to sustain** the system **until phaseout are considered in the production decision.** These plans include responsibilities and funding for configuration management, engineering support, supplier identification, and configuration updates of factory test equipment to the current fielded configuration of the produced item.

TIMELINE




Key factors in the risk equation are operational utilization, spares provisioning, design stability, adequacy of technical and reprocurement data, and quality of spares manufacturing and repair process.

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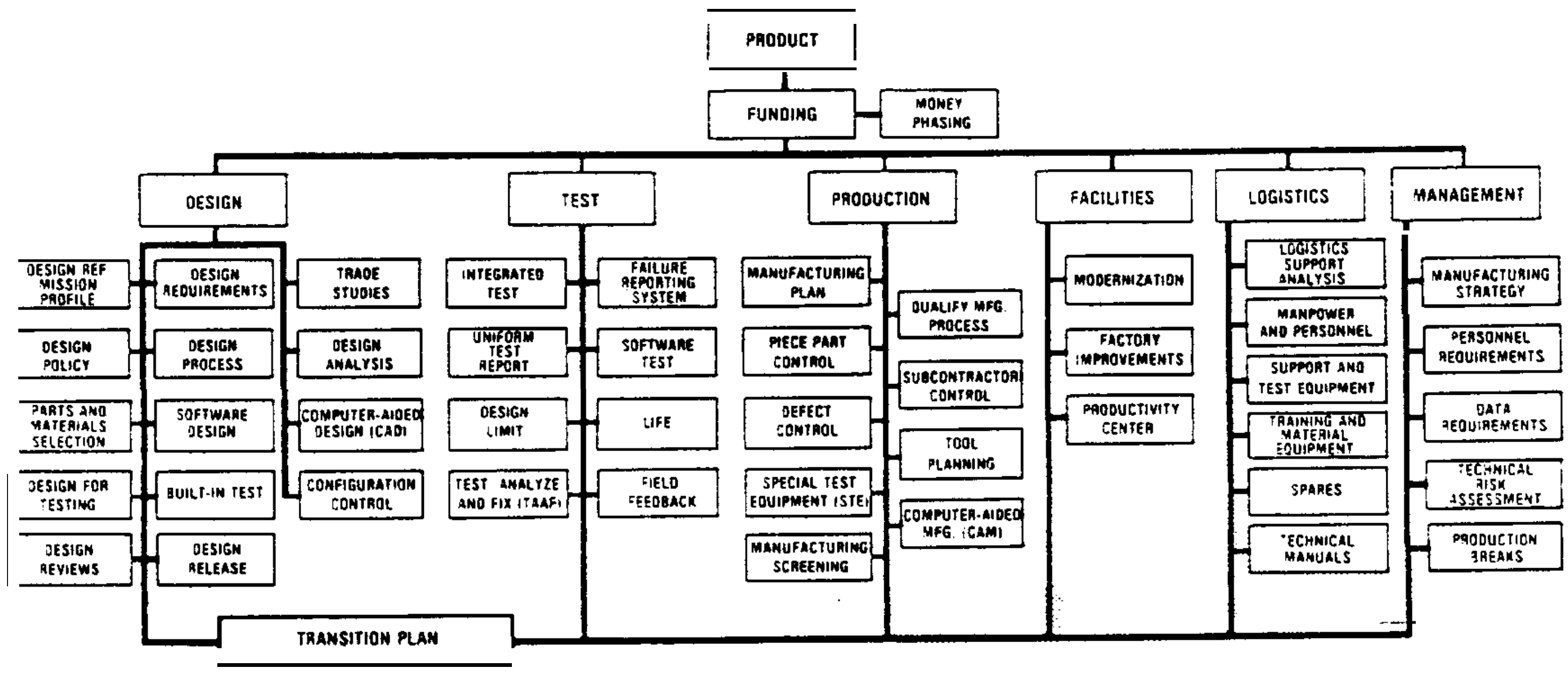



## TECHNICAL MANUALS

AREA OF RISK

Technical manuals frequently do not match the production configuration of the equipment supported. The manuals are difficult to read and understand. These deficiencies cause delays in operational testing, low readiness rates, increased revisions change activity, and increased spares and data costs.

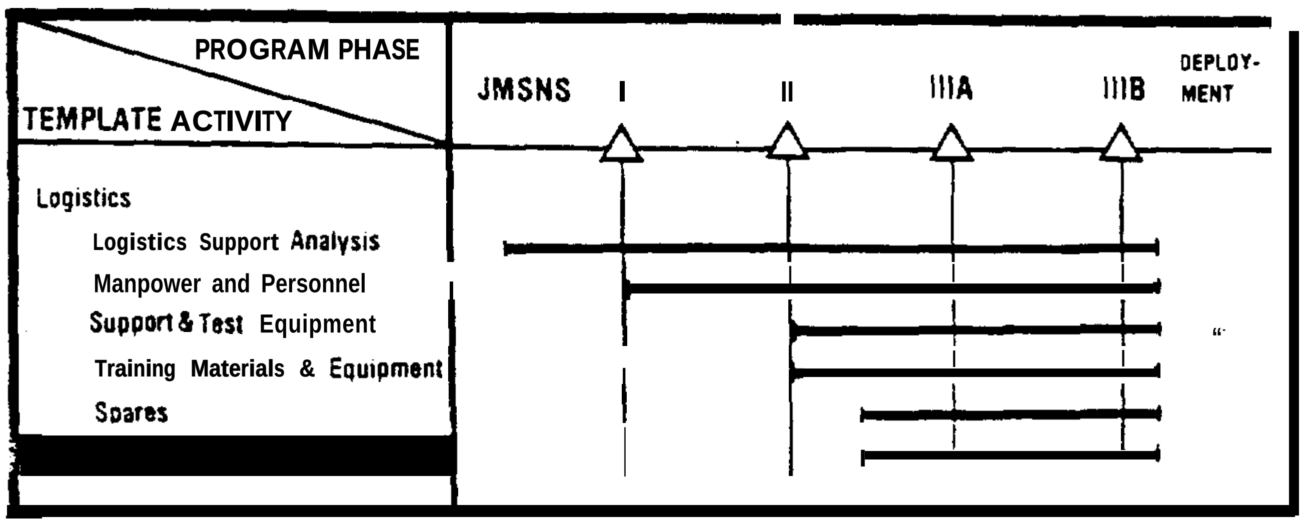
OUTLINE FOR REDUCING RISK

- A clear delineation of Government and contractor responsibilities in the development, verification, validation, and publication of technical manuals is outlined in the ILS plan.
- Automated processes (such as the use of computer-aided engineering drawings as illustrations) are used in technical manual preparation. These processes are encouraged by RFP requirements and evaluations during source selection.
- The LSA process analyzes technical options for portraying information including embedded and paperless delivery.
- Maintenance tasks identified through the LSA process provide the data base used in technical manual development.
- Draft manuals are validated and verified before final preparation and publication. Equipment availability to be used in verification and validation is specified in the contract.

- Automated readability analyses are used to verify that the level of the document matches the level specified.

- The milestone schedule includes interim manuals for initial training.

## TIMELINE




The development of technical manuals must be keyed to support of training requirements, engineering development models, equipment evaluation, initial production units, and update programs.

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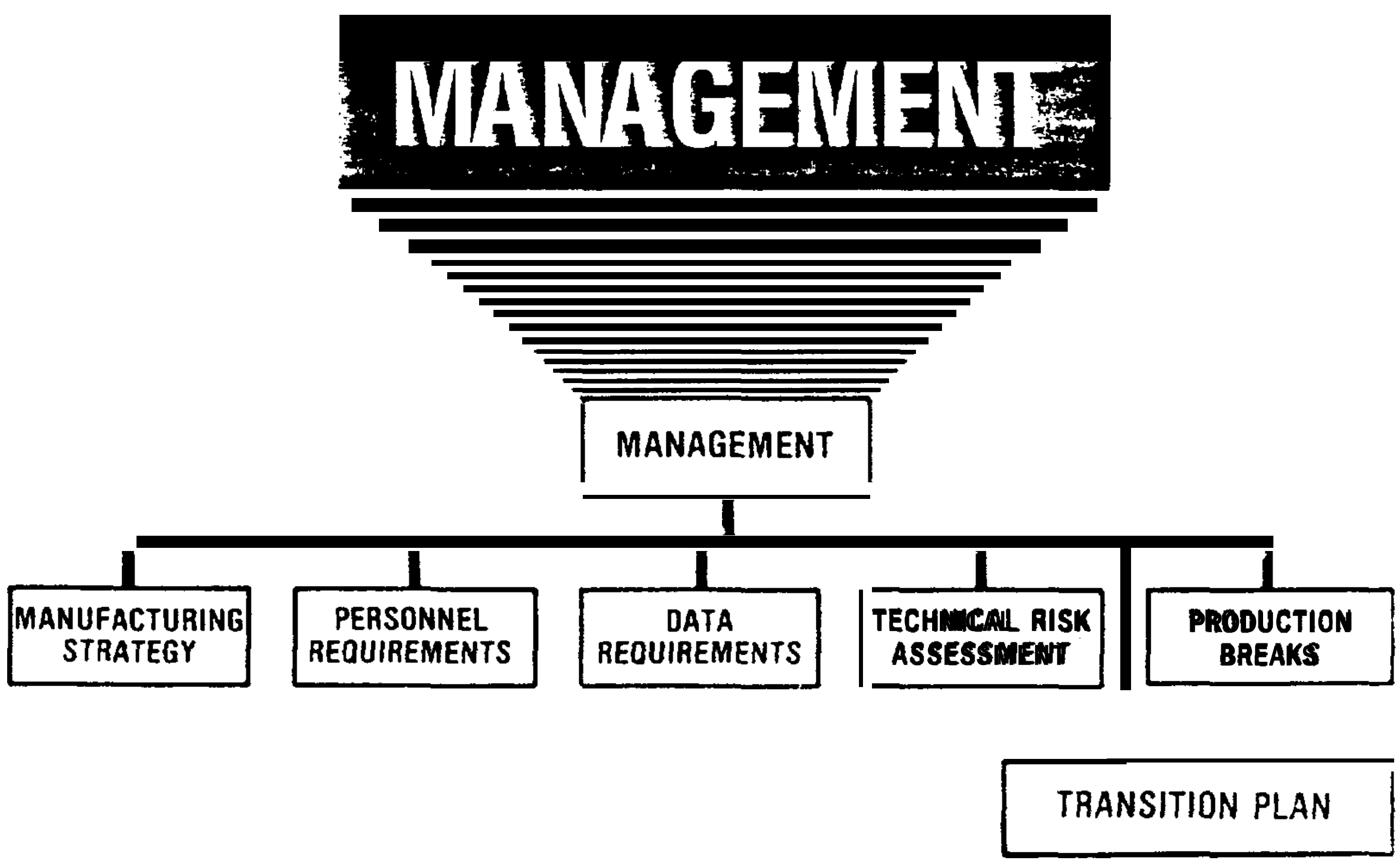
MANAGEMENT
MANAGEMENT
MANUFACTURING STRATEGY
PERSONNEL REQUIREMENTS
DATA REQUIREMENTS
TECHNICAL RISK ASSESSMENT
PRODUCTION BREAKS
TRANSITION PLAN

# CHAPTER 9

## INTRODUCTION FOR MANAGEMENT CRITICAL PATH TEMPLATES

Our free enterprise system relies heavily on the law of supply and demand. When a supplier has the capability to make a product for which there is sufficient consumer demand, the resources of both the supplier and the customer are applied to ensure that the product is delivered for the price agreed upon, is received on or before the desired date, and performs the required functions. The risk drivers in this process include the quality and experience of the people assigned to the project. More specifically, the industry supplier must have the people resources to design, test, and produce an acceptable end item. To ensure that customer requirements, and any necessary changes thereto during the acquisition process, are communicated effectively to the supplier, the Government also must have competent people resources to provide clear direction and evaluate progress throughout the process.

Without adequate numbers of competent people in industry and Government, there is an extremely high risk of having an unacceptable product. Although material and time are very important resources requiring effective management, people are the key to a successful program.

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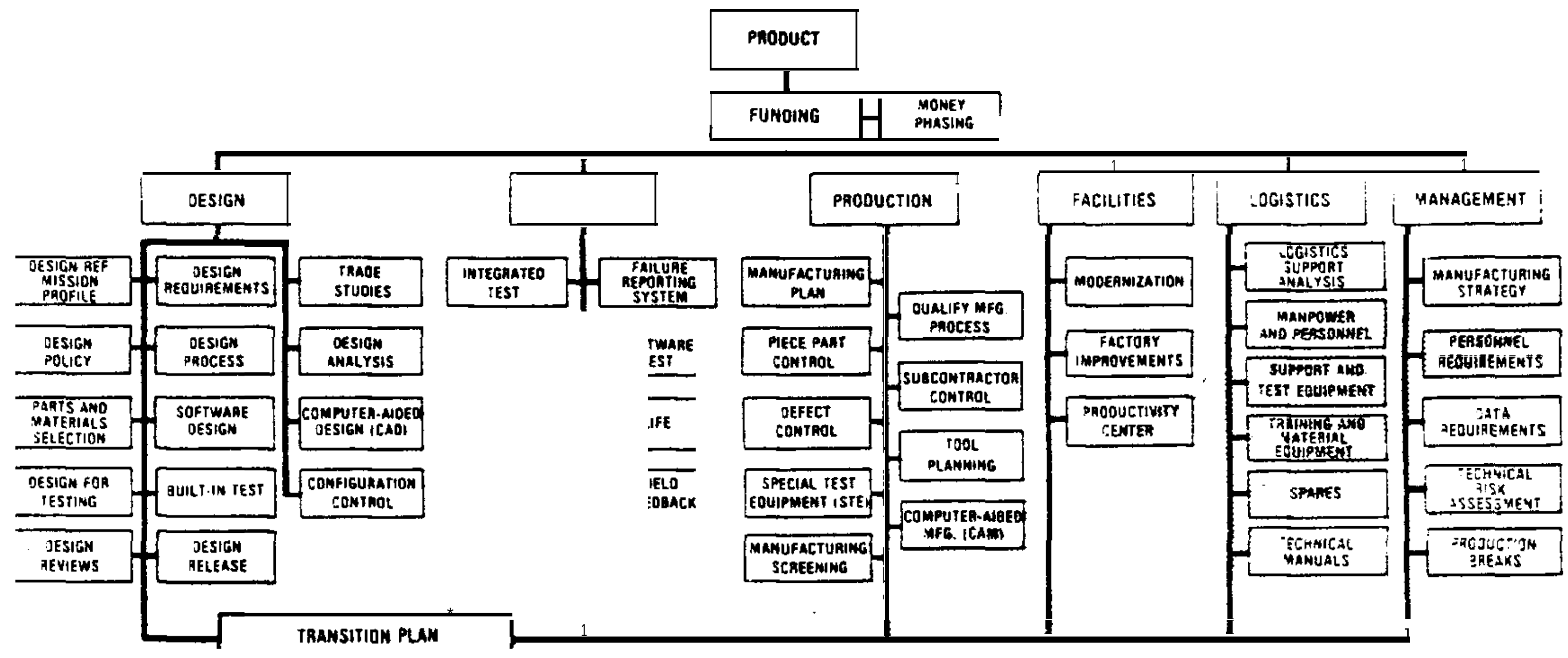



## MANUFACTURING STRATEGY

### AREA OF RISK

One of the first tasks for the newly assigned program manager is the development of an overall acquisition strategy. Construction of the program acquisition strategy without due consideration to the manufacturing elements is a key area of risk to the capability of the industrial base meeting the schedule, performance, and quality desired of the end item. If the principal contractors do not know what is expected of them by the Government, they will be uncertain and reluctant to make the proper financial and personnel resource decisions necessary for facilitization, industrial modernization, labor commitments, subcontractor or vendor structure, and foreign and domestic technology and production sharing agreements. Inadequate and unnecessarily imprecise production planning information increases program risk to the contractors and adds delay and indifference to industrial market participation in the program. Resulting inefficiencies will increase substantially production and support costs.

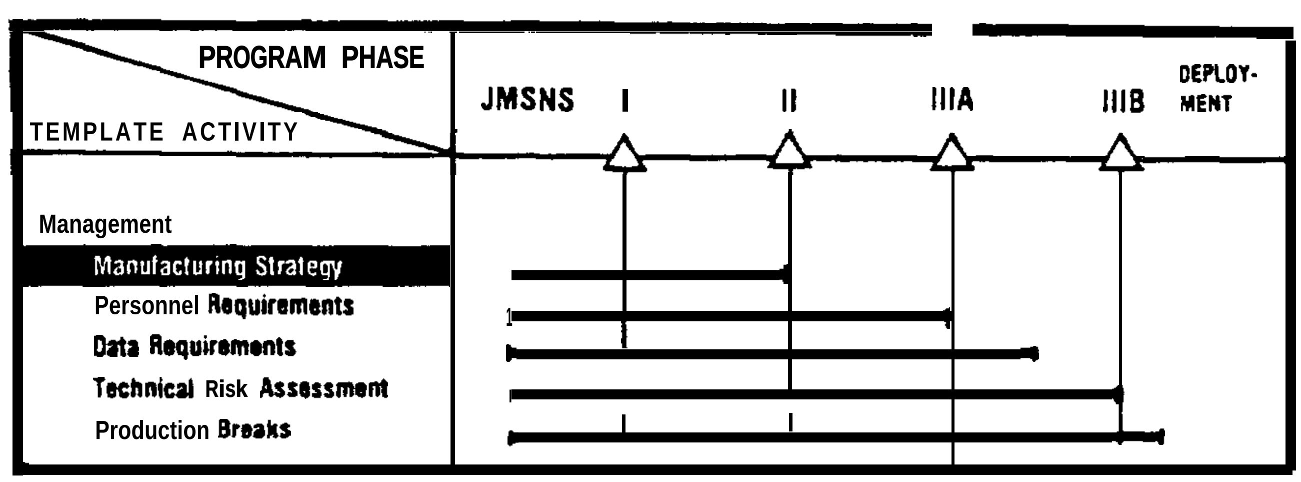
### OUTLINE FOR REDUCING RISK

- A manufacturing strategy as specified by DoD Directive 4245.6 (reference (h)) is outlined by the program manager as part of the initial acquisition strategy. The manufacturing strategy is refined progressively during the program's conceptual phase so that a sound, comprehensive manufacturing approach is available for dissemination with the solicitations for the development effort.

- Demands on the industrial base will be discernible readily from stated inventory objectives, operational capability dates, initial production requirements, delivery profiles, and production surge requirements.

- Maintenance, logistics, mobilization, and surge planning information enables assessing the demands on production capacity from spares and test and support equipment requirements.
- Use of strategic and critical materials and vendor manufacturing capabilities is projected, including offshore requirements.
- Critical manufacturing technologies needed to efficiently produce the concept and the design are identified and pursued through appropriate RDT&E projects.
- Peculiar system and component manufacturing test equipments are scheduled for development and use.
- The contracting scheme is compatible with program risk and needed levels of Government visibility and control.
- The contractors are aware fully of Government plans for dual sourcing and "breakout" of Government-furnished equipment so that rights in data and technology transfer issues are resolved expeditiously, Procurement of necessary technical data is an integral part of the development effort.
- The Government manufacturing strategy is translated readily into contractor production and transition planning documents that convincingly show the contractors' appreciation of and capability to respond to the magnitude and complexity of the manufacturing effort and their willingness to participate in mobilization, surge, and productivity enhancement projects.
- Production matters are weighted heavily in engineering development source selection evaluations and the contractors are so informed.

TIMELINE




A manufacturing strategy should be developed at the initiation of program development to reduce risk while meeting cost, schedule, performance, and quality of the production items. As development progresses, the manufacturing strategy should be refined and updated so that a sound manufacturing approach is in place at the start of production.

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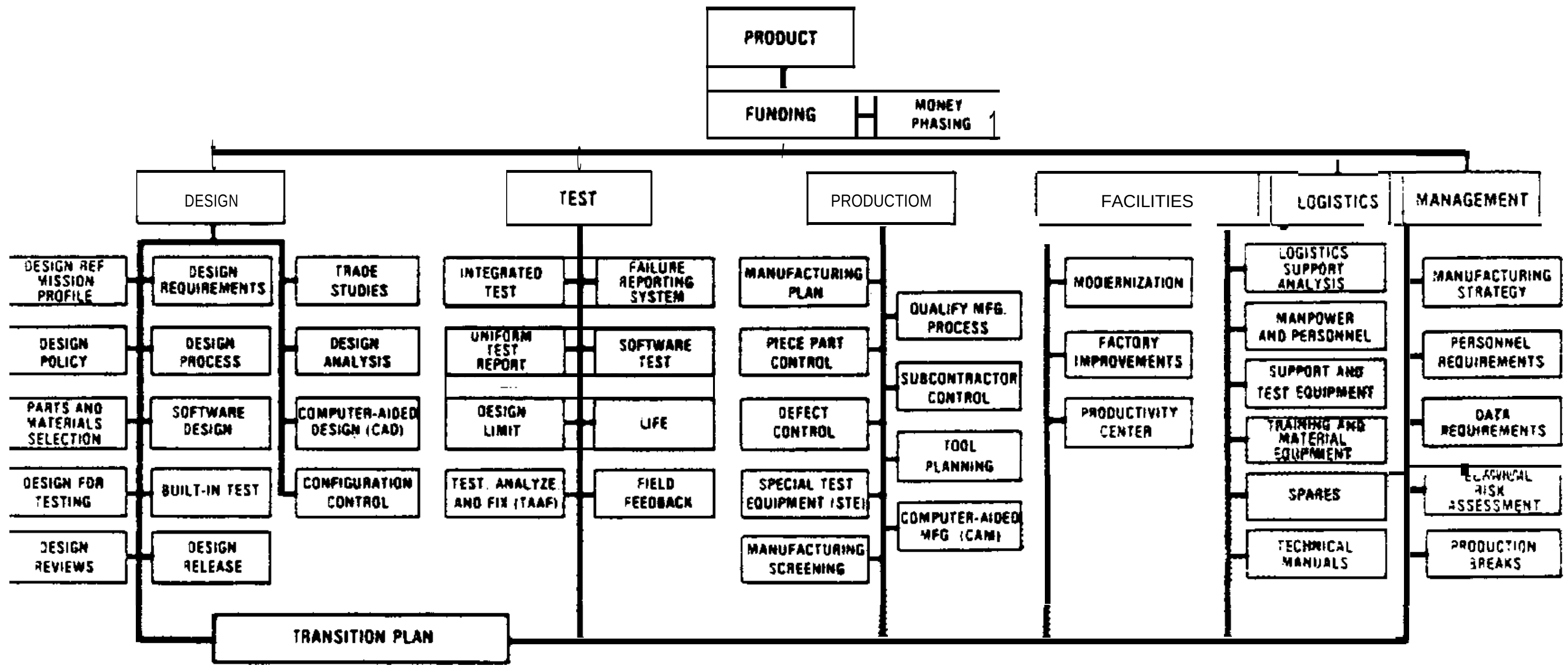


**PERSONNEL REQUIREMENTS**

## AREA OF RISK

It is a common practice in both industry and Government for program managers to be supported by a small number of key staff personnel collocated in the program office and by a large number of functional area experts who provide their support using a matrix management approach. Contractor program managers may lack the experience to orchestrate the entire effort from drawing board to finished product. Government program managers may likewise lack acquisition experience and proven leadership ability, and tour lengths are often too short to see the program through to completion. Engineering and manufacturing talent may lack critical continuity and corporate knowledge. For example, design engineering may be left to recent college graduates because the more experienced design engineers have been promoted to new fields of endeavor. Functional support personnel are also in the critical path, and the recruitment, training, and retention of competent, experienced personnel may not be a continuing corporate objective. History has proven that those programs for which Government or industry top managers only gave lip service to the precept that states “people are our most important resource” have suffered and often failed.

## OUTLINE FOR REDUCING RISK

- Career progressions are defined for prospective program managers, and available formal training such as the Defense Systems Management College and informal training such as training with industry programs (for DoD personnel) are used.

- program manager tours are extended and stabilized, particularly in the Department of Defense, and civilian program managers are used in the Department of Defense on a selected basis. Stability considerations argue strongly against changing program managers and key staff and functional support personnel at major program - milestones.

- A program manager never is assigned more than one major program.

- The use of matrix management, a proven concept, is coupled with as much collocation of key functional support personnel as practical.

- Line managers are involved in the recruitment, training, and retention of key technical personnel rather than delegating all such responsibility to the personnel support organization. To provide DoD line managers with greater control over personnel functions, innovative techniques, such as the Civil Service experiment being conducted at the Naval Weapons-Center (NWC), China Lake, and Naval Ocean Systems Center (NOSC), San Diego, are considered.

- Personnel with production experience are critical particularly in Government organizations because manufacturing operations usually are contracted with industry. Career development and training programs with a production orientation are supported zealously by the Military Services, and program managers ensure that their personnel attend or have commensurate experience.

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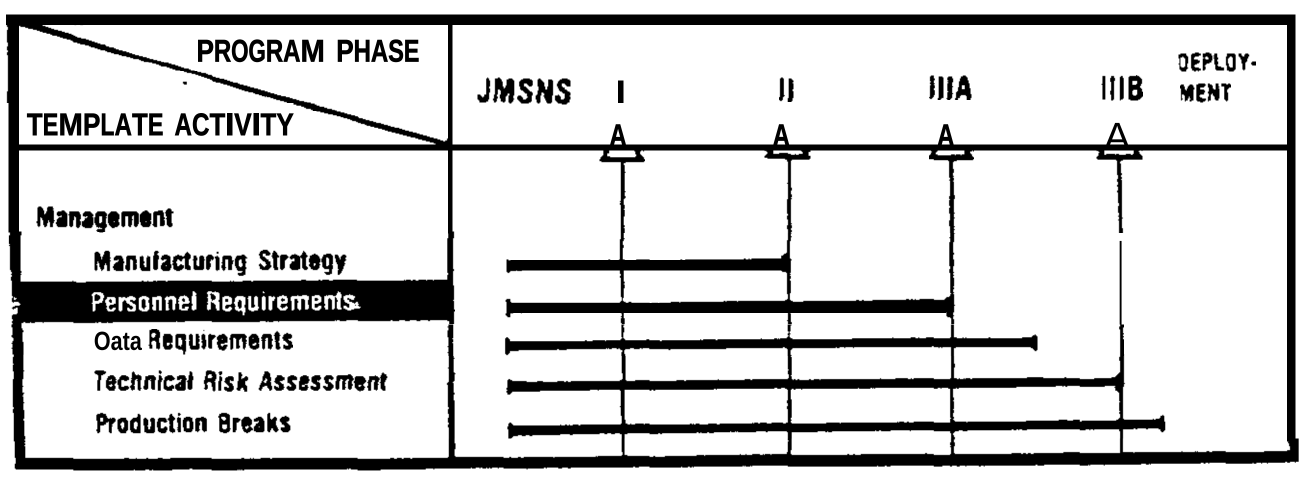


Personnel resources are the key determinant of successor failure throughout the life cycle of any program. To recruit, train, and retain the people necessary to ensure success, it is essential that Government and industry couple effective management and sound leadership during every program phase, including the transition from development to production.

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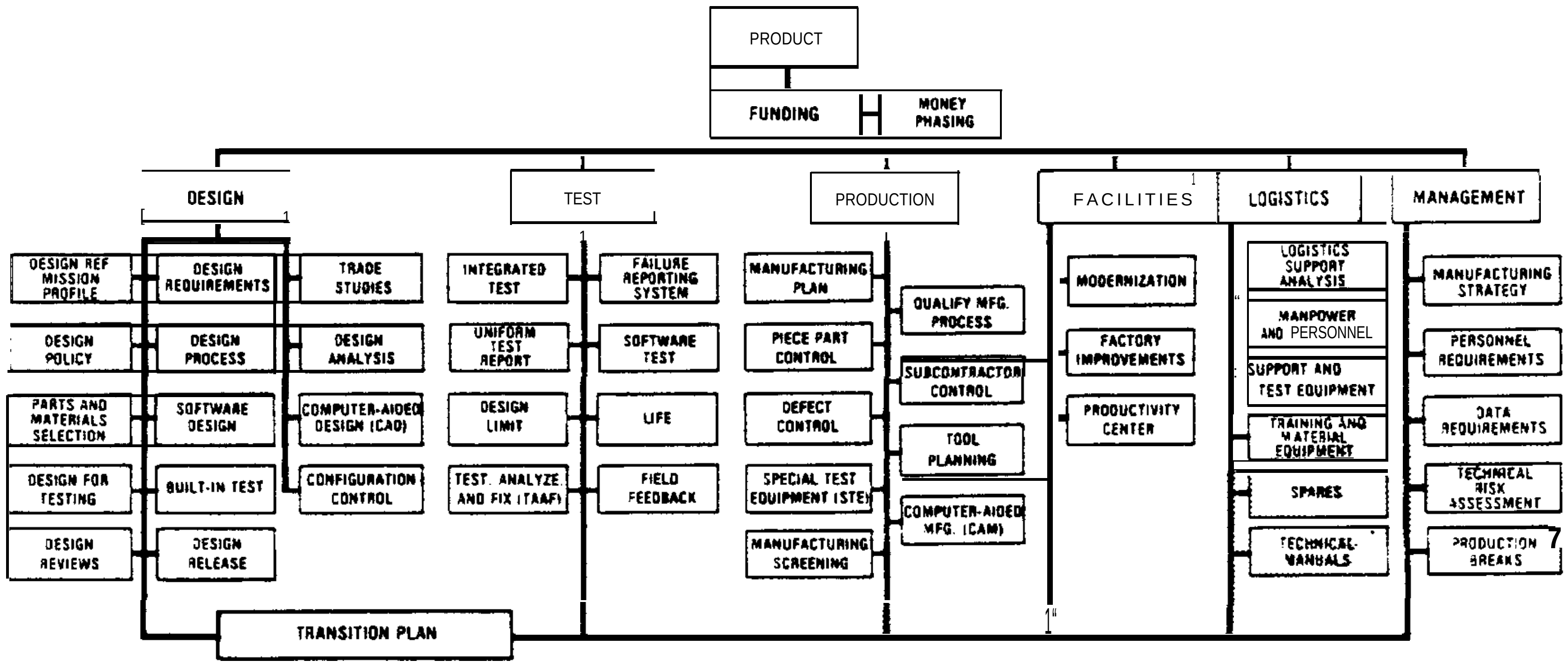


## DATA REQUIREMENTS

## AREA OF RISK

The Government asks for too much technical data in their procurements, which increases the risk of cost overruns. Redundant data also may be procured by different Government functional organizations and the program office that did not coordinate their data requirements before contract definition. Often, this is a direct result of using a boilerplate list of data requirements when the request is submitted by the various Government offices responsible for the procurement. It is estimated that direct costs for data range from 6 to 20 percent of contracts, not including the overhead costs and the cost to the Government to process, review, and manage the data. A corollary problem is the degree to which any potentially useful data is evaluated and introduced into the decision making process. On the one hand, too much data is required and, on the other, not enough data is used for better program control. Control of data requirements has been sporadic at best and, even though the problem of poor data management has been identified in various studies over the past 20 years, it receives little emphasis because of little top level commitment.

## OUTLINE FOR-REDUCING RISK

- All procurement data requirements are reviewed using an effective data review board before contract award, to ensure that the data received will satisfy the Government's needs, is in a format suitable for customer use, and is not redundant.
- An integrated data management system is established both in Government and industry for each major procurement. The objective is to tailor the technical data requirements to the needs of each program.
- Electronic data transfer is used. Pertinent data required by the Government can be requested by accessing the customer data base. The requested data can then be exercised in the Government's data base to extract the required information.

- The data requirements for a major program are reviewed at a level high enough to ensure that redundant data is not being requested by the different disciplines within the program office and its functional support organizations.
- Technical data libraries are established for ease of data retrieval, and the data is kept current.
- Data requirements are reviewed during each phase of the program to ensure that data being procured meets the needs of that particular program phase.
- Data is procured using well-defined data requirements lists, reasonable cost estimates, and realistic schedules.

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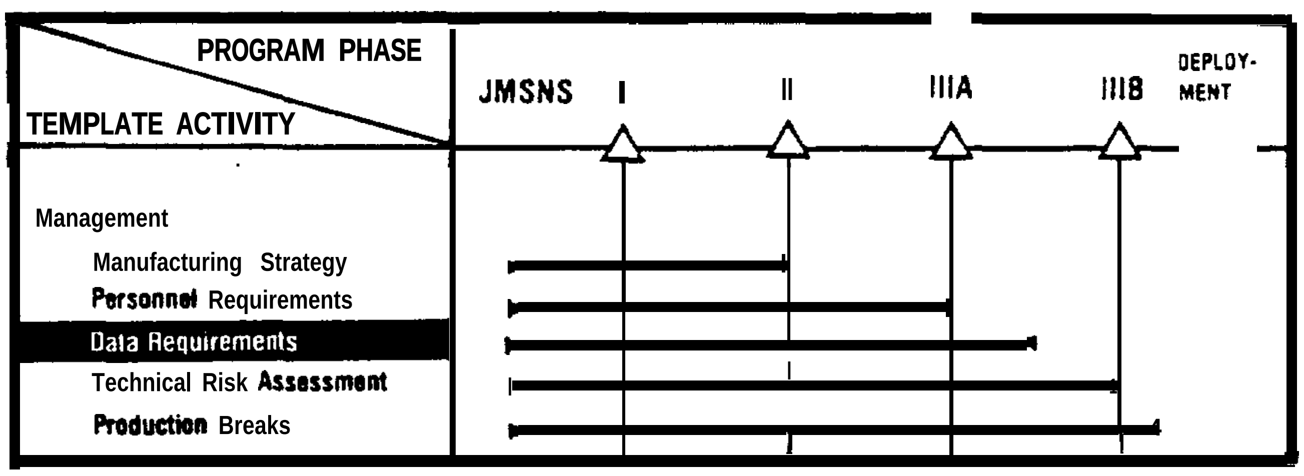


Useful data, properly applied during the decision making process, will ensure that the system being procured meets all the technical requirements and that the necessary reprocurement information is available when needed. An integrated data management plan developed at the start of the program and approved at the appropriate management level, should lay out the technical data requirements for ail phases of the program to reduce management risks.

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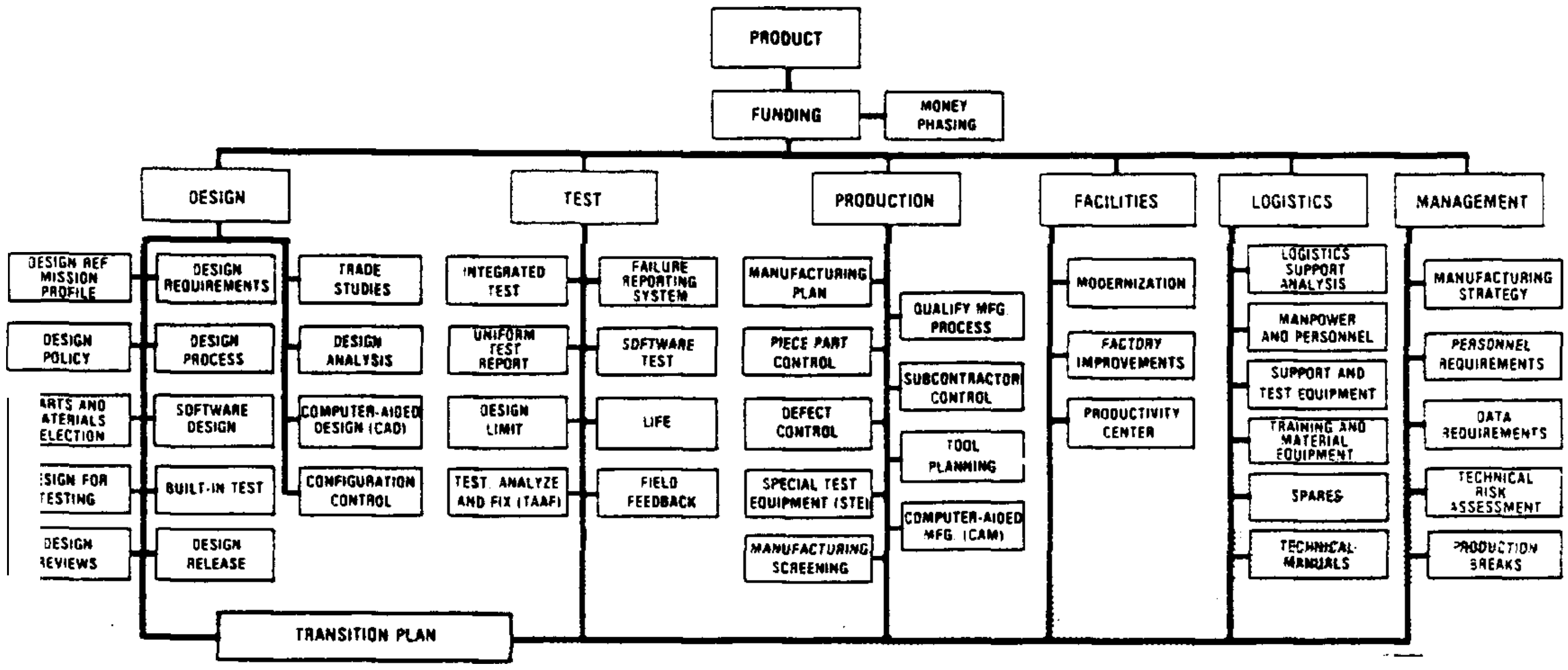


**TECHNICAL RISK ASSESSMENT**

AREA OF RISK

The track record of major defense systems acquisitions has been poor over the past several years, as manifested by the length of the acquisition cycle, the unsatisfactory levels of effectiveness, and the pressure to reduce life cycle costs. In spite of numerous attempts to improve the management-oriented Defense System Acquisition Review process, the lack of consistent and predictable success has resulted in renewed interest in upgrading the process by an infusion of technical discipline. The 1981 DoD Acquisition Improvement Program not only identified the root cause of acquisition problems to be “uncertainty” but also called for increasing DoD efforts to quantify risk and for expanding the use of budgeted funds to deal with uncertainty. Since risk and the degree of uncertainty are synonymous and directly proportional to the seriousness of the acquisition problems faced by Government and industry program managers, why have many years of alleged emphasis on technical risk assessment achieved so few results? It must be concluded that management ignorance of technical risk assessment is itself a major source of risk in the transition from development to production.

OUTLINE FOR REDUCING RISK

- Technical risk management is specified as a contractual requirement, and early implementation in the development process is required.
- All areas of risk are identified as early as possible in the development cycle. A specific set of tracking indicators is determined for each major technical element (design, test, and production) as well as for cost and management.
- Plans are developed to track, measure, assess, and adjust for identified risks using a disciplined system that can be applied by managers from a variety of positions

within the Government and the contractor organizations. This system provides a continuous assessment of program health against quantifiable parameters.

- Risk drivers are understood adequately by contractors, using qualified design and production engineers knowledgeable of the risk drivers, to identify and reduce program technical risks.
- Technical problems are highlighted before they become critical.
- Hasty shortcuts are avoided, mission profiles are reviewed, and existing analysis tools are used while implementing the technical risk assessment system.
- Test programs are structured to verify that high risk design areas have been resolved.

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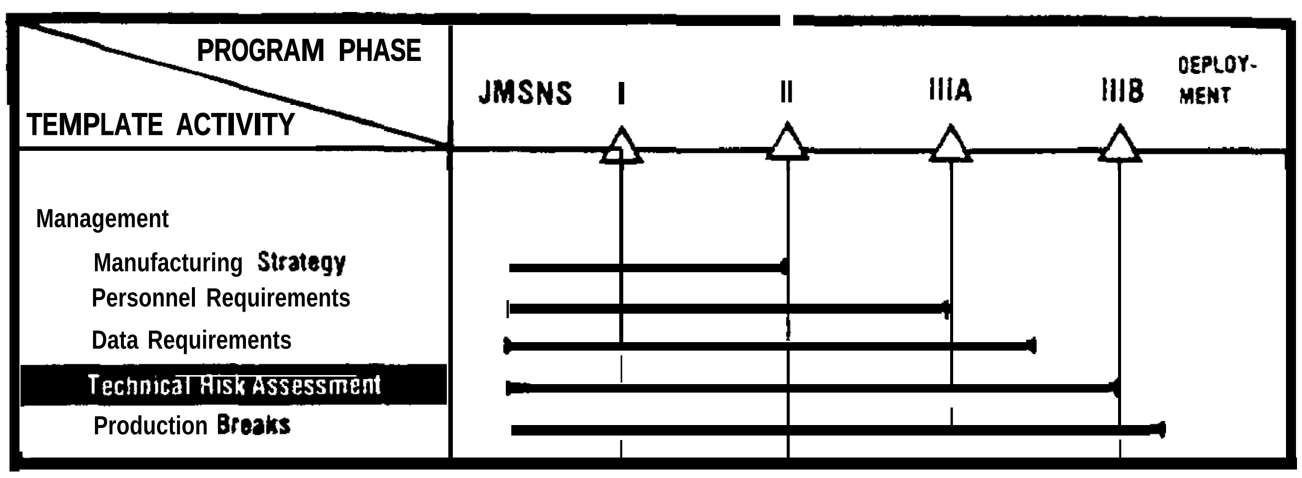


A technical risk assessment system should provide all levels of management with (1) a disciplined system for early identification of technical uncertainties, (2) a tool for instantaneous assessment of current program status, and (3) early key indicators of potential success or failure. To be effective, a technical risk assessment system should be initiated at the start of the program and function throughout the development and production phases.

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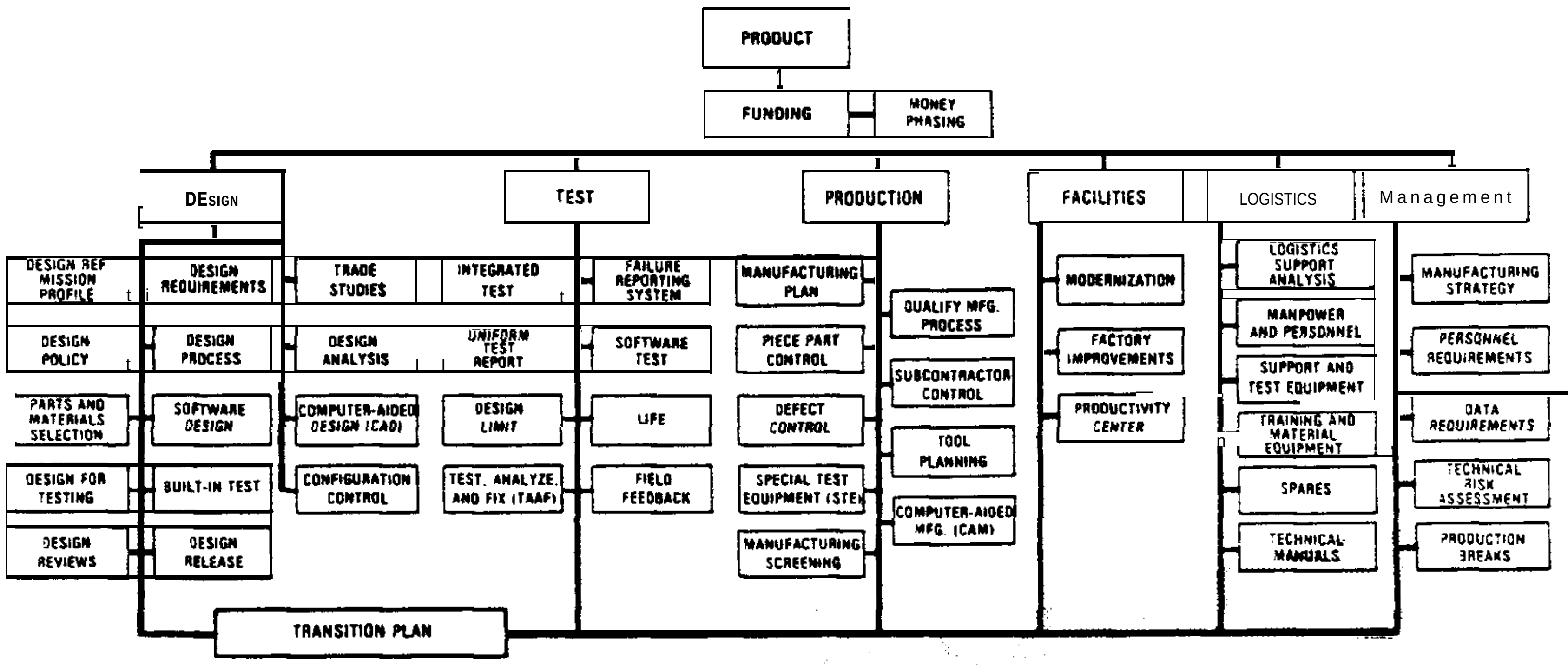


## PRODUCTION BREAKS

### AREA OF RISK

Changes in production schedule range from reduced delivery rate (stretchout) to a complete shutdown of the production line (production break). Stretchouts and production breaks increase both technical risk and cost. Factory space, tooling, and equipment are idled, and in the worst case, may be eliminated. Publications and handbooks lose currency. Production flow is interrupted and benefits from assembly improvements and automation are lost. Experienced manufacturing and engineering personnel are either reassigned or dismissed. Morale suffers, teamwork is less apparent, problem identification and resolution become much more difficult to reestablish, and production efficiency degrades noticeably. Design improvements are less effective and less timely. Small suppliers and vendors whose orders represent much larger percentages of their total business are less able to adjust, and in the worst case, even sole source suppliers and vendors have been forced out of business.

### OUTLINE FOR REDUCING RISK

- Experience has shown that the classic result of a production break is as illustrated in figure 9-1. The ideal solution, of course, is never to permit a break to occur. However, when the realities of the budget process increase the potential for a Government-mandated production break, understanding the impact might help the arguments for softening such a decision or preventing it from being made at all.

- The loss of learning that often includes a loss of process capability results in an overall program cost increase and a higher quantity of units produced before unit cost reaches the value it would have been without a break in production. A significant reduction in production rate, to a "misery rate" level, has similar effects.
  - To prepare a case for modifying a production break decision, use the following method to compute the cost of the loss of learning (see figure 9-1 .):

- Determine value of learning for improvement before the break or stretchout.

– Determine percentage loss of learning for duration of break or stretchout and compute new cost of first unit produced after break or return to original production rate.

– Locate the new point for initial unit cost following break/return to original production rate. This point will correspond to the same quantity along the abscissa that existed just before the break/reduction in rate.

— Develop the new forecast learning curve for the continuation of production.

– Loss of learning cost is the difference between the cost of producing the quantity of units following the break or stretchout versus the cost of the same quantity without the break or stretchout.

● Use of multiyear contracting minimizes the risk of production breaks or stretchout.

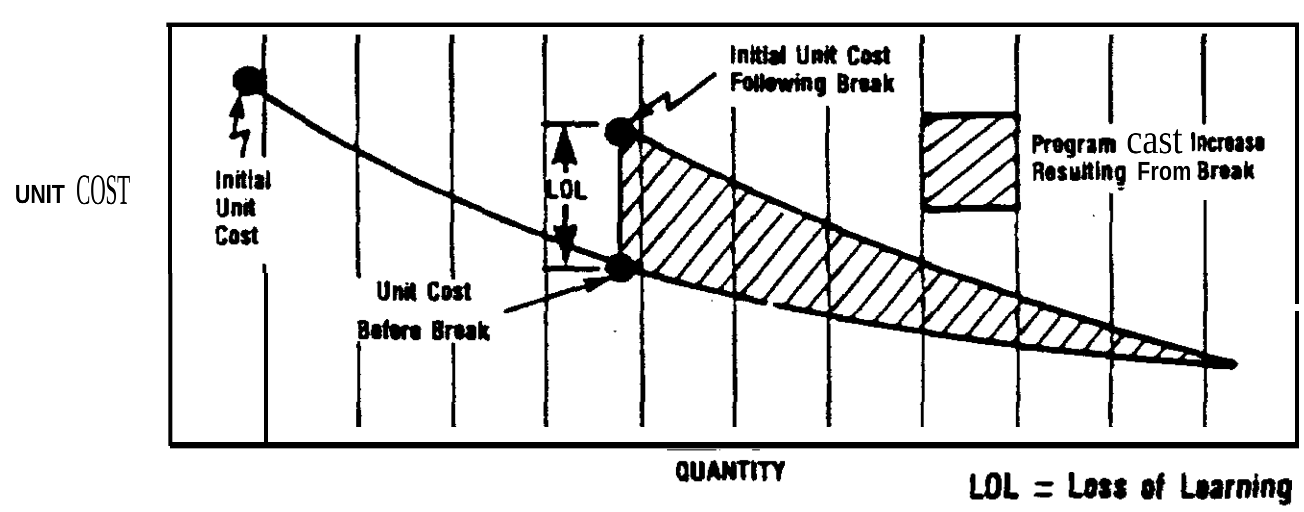


Figure 9-1. Production Break Impact on Learning Curve

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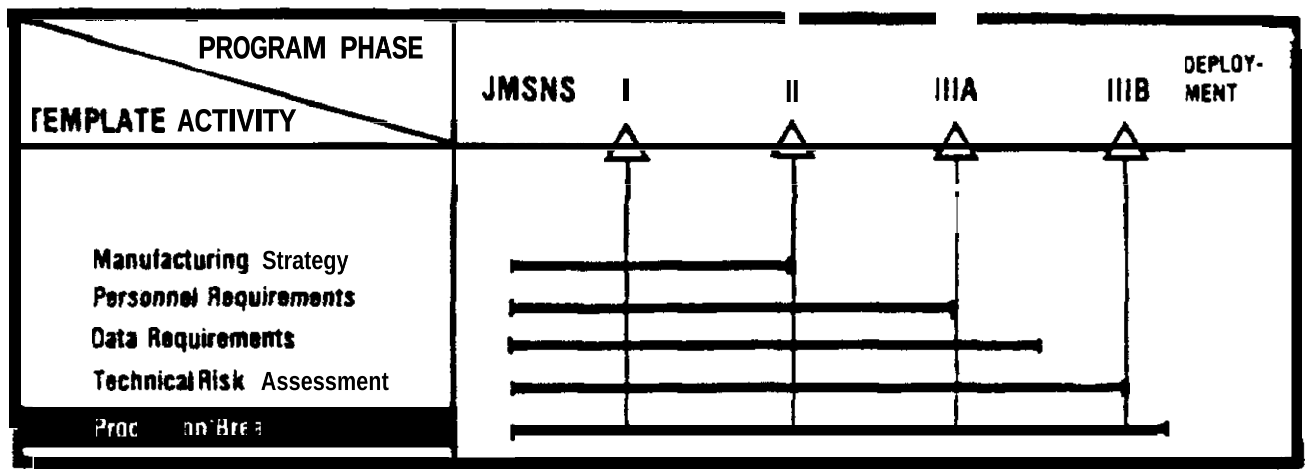


The increase in production efficiency and attendant reduction in unit cost reflects the benefits of an uninterrupted learning curve, that is, no break in production, starting with initial production at Milestone IIIA.